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OWNER'S INSTALLATION AND OPERATING MANUAL

DS9000 DIGITAL
Speed Controller

For your safety and for proper operation, please take time to carefully read all instructions before installing and operating this unit.

WARNER ELECTRIC
SECO ELECTRONICS DIVISION
DANA
Route 4, Hwy. 29 • Lancaster, SC 29720 • (803) 286-6927

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1.0 INTRODUCTION AND PRODUCT DESCRIPTION

1.1 GENERAL INFORMATION

This manual outlines installation and operating practices for the DS9000 series of Digital Speed Controllers. It also contains a brief description of the product and includes specifications. Before installing or operating the equipment, read and understand this manual.

1.2 DIGITAL SPEED CONTROLLER

The Seco DS9000 Digital Speed Controller is a closed loop digital speed regulator which can operate as a Speed Set point controller or as a precision follower when used with an AC or DC drive. The controller will maintain a long term speed accuracy of ±.01% of top speed and the 16-bit microcontroller used in the unit provides a 10ms control loop update time, giving tight control and good stability.

The DS9000 allows up to eight preset speeds and two sets of the following parameters, maximum speed, minimum speed, acceleration time and deceleration time to be set by the user. Other parameters such as scaling factors and stabilizing gains are also adjustable. An easy to read digital readout shows speed in user selected engineering units. When used as a follower, the digital readout will show the speed of the controlled motor or the speed of the reference.

The DS9000 will allow two complete sets of operator adjustments to be preset. This means the unit can be set up to handle two different applications or products. Selection of the operating set of parameters is by terminal strip connection at the rear of the unit.

The 0-10VDC output signal to the AC or DC drive being controlled is isolated from common on the DS9000 and can be connected to non-isolated motor controllers.

1.3 FEATURES

-Closed Loop Set Point Controller - long term accuracy ±.01% of top speed

-16 bit microprocessor controller

-Fast Response Time - internal up-date time 10 ms.

-Feedback Rate Programmable - 30 - 600 pulses per revolution

-Feedback Signal Selectable - Magnetic pick-up
Encoder
Open collector Hall Effect type

-Speed Control or Follower Mode

-Readout of Speed in user selected Engineering Units or RPM

-Follower Mode speed readout displays controlled motor or reference signal

-Isolated output signal to AC or DC motor control, 0-10VDC,5mA

-Speed setting resolution of 1 RPM

-Two selectable sets of independent parameters can be programmed

-Four Preset Speeds or Ratios within each set of parameters

-Speed or ratio may be changed while operating

1.4 Specifications

AC Supply	115/230VAC ± 10%, 15VA
Ambient Temperature	0-50°C
Altitude	0-1000 M or 3300 ft.
Accuracy	Speed holding ± 1 RPM Zero cumulative error in follower mode
Response	10 ms internal up-date time
Display	4 digit, .6", RED L.E.D.
Feedback Sensor	1) Magnetic pick-up (Seco MTK type) 2) Encoder 3) Open collector proximity switch
Input Frequency Range	Master Mode Max. Frequency 25KHz, Min Frequency 30Hz Follower Mode Max. Frequency 20KHz, Min. Frequency 50Hz
Mode	Speed Set Point controller 0-1800 RPM Follower - ratio adjustable 0-999.9% or equivalent.
Speed Range	35:1 with 60 ppr magnetic sensor on 1750 RPM motor 500:1 with 600 ppr Encoder on 1750 RPM motor
Inputs	Feedback pulse train Reference pulse train (Follower Mode only) Start/Stop, 5-30V Isolated sink or source to Start 115V/230V AC 50/60 Hz 15VA Security (prevents unauthorized parameter changes) Speed/Ratio Parameter (selects one of four possible preset speeds or ratios) Parameter Data Table (selects one of two unique data tables, A or B)

Outputs	Drive control signal 0-10V DC, (5mA max.), isolated from DS9000 common Excessive following error indication for Follower Mode +5VDC power supply for encoders (max current 40mA)

1.5 Front Panel Controls

The DS9000 Front Panel has a 4-digit LED readout, 6 keypad controls, and 4 LED status indicators. The keypad controls are:

PROG - Selects Program Mode, allows adjustment of:

Operator Adjustments

- 4 Preset Speeds/Ratios
- Minimum Speed
- Maximum Speed
- Acceleration Time
- Deceleration Time

Set-up Adjustments

- Feedback resolution of controlled motor
- Feedback resolution of reference signal (Follower Mode)
- Readout Scale Factor and Decimal Point placement for Controlled Motor
- Readout Scale Factor and Decimal Point placement for Reference Signal
- Proportional Gain (Stability)
- Integral Gain (Stability)
- Position Error Gain (Follower Mode)

TACH/REF	Selects display of either Tach signal or Reference Set-point while running.
UP	Increases speed or data values or scrolls up the Program parameters.
DOWN	Decreases speed or data values or scrolls down the Program parameters.
VALUE/CODE	Changes display to either actual value of a parameter or parameter name (used in Program Mode only).

HI/LOW — Allows displayed value to be changed, either one count at a time (LOW range) or 100 counts at a time (HI range) by the Up or Down Arrow Key. In the Follower mode, the HI range changes the displayed value by 10 counts at a time while running to allow for smaller maximum incremental ratio changes.

LED DISPLAYS:

HI ADJ LED — Indicates that HI/LOW key input is in High mode.

LOW ADJ LED — Indicates that HI/LOW key input is in Low mode.

TACH LED — Indicates that display is actual speed of controlled motor or reference input
Indicates Program mode when LED is blinking

REFERENCE LED — Indicates that display is the speed set-point.

NOTE: The Tach and Reference LED are only used while the Start input is on.

1.7 REAR PANEL FUNCTIONS

The rear panel of the DS9000 contains 3 terminal strips to which the connections are made and has a number of DIP switches to allow various parameters to be set for a particular applicaton.

1.7.1 DIP SWITCH FUNCTIONS

Switch Position	Function
1	OFF - Setpoint Controller Mode ON - Follower Mode
2	OFF - Enable PI and Position Control (Closed Loop Control) ON - Disable PI Controller in Set Point Control Mode (Scaled 0-10 V for 0-1800 RPM) - Disable Position Controller in Follower Mode*
3	Controlled Motor Feedback Type OFF - Magnetic Pickup or Zero Cross Sensor ON - Encoder or Open Collector (input impedance 3.3K)

4**	Reference Motor Feedback Type OFF - Magnetic or Zero Cross Sensor ON - Encoder or Open Collector (input impedance 3.3K)
5**	Tach Display Value (Enabled by Tach/Ref Key, applicable for follower mode only) OFF - Tach Shows Reference** RPM or Engineering Units ON - Tach Shows Controlled Motors RPM or Engineering Units
6	OFF - Not used ON - Displays DS9000 System revision number upon power up

Note: Switches 1, 3, 4 and 6 can only be changed when the DS9000 is not running, i.e. the START input is not on.

* When used as a Follower Controller, Dip Switch #2 in the ON position will maintain closed loop speed control but will not maintain position synchronization of the Controlled motor with the Master Reference.

** Follower Mode only

1.7.2 TERMINAL CONNECTION POINTS:

See Fig. 1 for connection information.

Connector	Terminal	Function
TB1	1	Start/Stop Input Common
	2	Start/Stop Input (+5-25VDC)
	3	Open selects Parameter Data Table A. Connected to TB1-12 selects Parameter Data Table B
	4	Open selects Group A. Connected to TB1-12 selects Group B
	5	Open selects PS1 in Group A or PS3 in Group B. Connected to TB1-12, selects PS2 in Group A or PS4 in Group B
	6	Open - Security Off. Connected to TB1-12 Security On
	7	Open collector output for customer connection, signals "OPLP" open loop error, signifies excessive following error in Follower Mode (25V max.,50mA sinking)
	8	Controlled Motor Feedback Signal Input
	9	Controlled motor Feedback Signal Common
	10	+5VDC (40mA max) source voltage for Encoder Feedback

	11	Follower Reference Signal Input
	12	Follower Reference Signal Common
TB2	1	AC Input For 115 VAC Input: Jumper TB2-2 to TB2-3 Jumper TB2-4 to TB2-5 For 230 VAC Input: Jumper TB2-3 to TB2-4 TB2-2, TB2-5 Unused
	6	AC Input
TB3	1	Isolated Analog Reference Output 0-10V
	2	Isolated Reference Common

Notes: Do not connect the case ground to the reference common. There should be no connections between terminal connection points TB1-3 through TB1-12 and the motor controller (TB3-1&2). Use isolated contacts (switches or relay contacts) to connect the appropriate terminal points to signal common, TB1-9 or TB1-12.

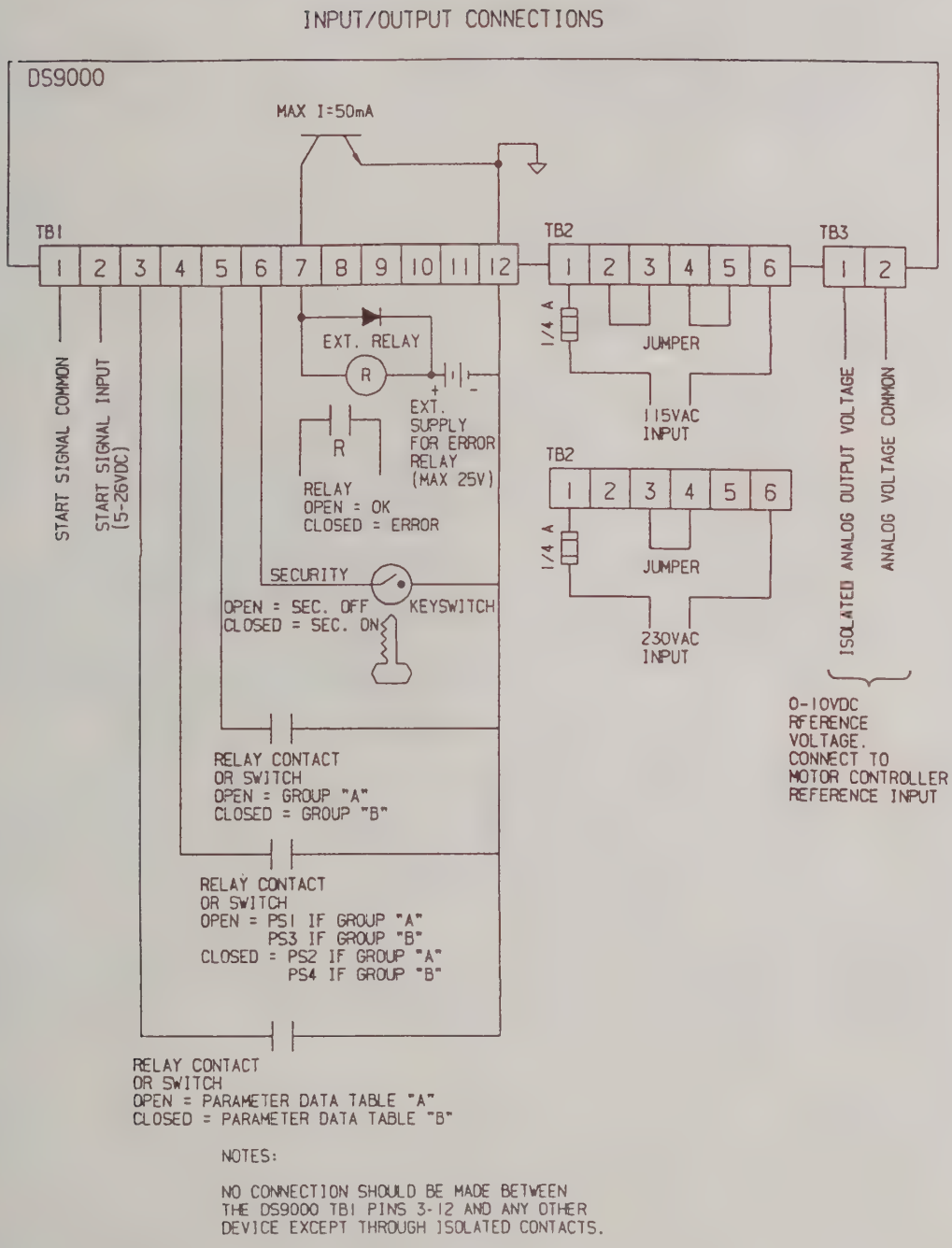
INPUT/OUTPUT CONNECTIONS
DS9000
MAX I=50mA
TB1
1 2 3 4 5 6 7 8 9 10 11 12
TB2
1 2 3 4 5 6
TB3
1 2
START SIGNAL COMMON
START SIGNAL INPUT (5-26VDC)
EXT. RELAY
R
EXT. SUPPLY FOR ERROR RELAY (MAX 25V)
RELAY OPEN = OK CLOSED = ERROR
1/4 A
JUMPER
115VAC INPUT
230VAC INPUT
SECURITY
OPEN = SEC. OFF CLOSED = SEC. ON
KEYSWITCH
ISOLATED ANALOG OUTPUT VOLTAGE
ANALOG VOLTAGE COMMON
0-10VDC REFERENCE VOLTAGE. CONNECT TO MOTOR CONTROLLER REFERENCE INPUT
RELAY CONTACT OR SWITCH OPEN = GROUP "A" CLOSED = GROUP "B"
RELAY CONTACT OR SWITCH OPEN = PS1 IF GROUP "A" PS3 IF GROUP "B" CLOSED = PS2 IF GROUP "A" PS4 IF GROUP "B"
RELAY CONTACT OR SWITCH OPEN = PARAMETER DATA TABLE "A" CLOSED = PARAMETER DATA TABLE "B"
NOTES:
NO CONNECTION SHOULD BE MADE BETWEEN THE DS9000 TB1 PINS 3-12 AND ANY OTHER DEVICE EXCEPT THROUGH ISOLATED CONTACTS.

Figure 1 - Connection diagram

1.8 SYSTEM PARAMETERS, OPERATIONAL, SETUP AND TUNEUP

The DS9000 allows the user to change or "program" eight Operational parameters in order to adjust the control to the particular application. Of the additional nine parameters, six are explained in sections 3.0 and 4.0 and the remaining three in section 5.0.

It is not necessary to go to PROG mode to change the currently selected active speed/ratio. When not in PROG mode the current value is displayed and it may be changed simply by pushing the UP or DOWN key.

The Operational parameters that can be changed while operating the unit are:

PS1 Preset Speed #1/ Preset Ratio #1 - Adjustable by UP and DOWN Arrow keys. Value limited by HI and LOW values. Readout scaling set by SCFO and decimal point position set by SCDO. As shipped the default value for speed ranges is 0-1800 (RPM).

PS2 Preset Speed #2/ Preset Ratio #2 - Adjustable by UP and DOWN Arrow keys. Value limited by HI and LOW values. Readout scaling is the same as PS1.

PS3 Preset Speed #3/ Preset Ratio #3 - Adjustable by UP and DOWN Arrow keys. Value limited by HI and LOW values. Readout scaling is the same as PS1.

PS4 Preset Speed #4/ Preset Ratio #4 - Adjustable by UP and DOWN Arrow keys. This preset speed is not limited by Max. Speed (HI) or Minimum Speed (LO) parameters. It can be set to SCFO (Max) or 0 (Min). Readout scaling is the same as PS1.

While in PROG mode the currently selected active speed/ratio will be indicated by a "-" before its corresponding number, example: "PS-2". If the status of TB1-4 and 5 are changed while in PROG Mode, the DS9000 will not recognize the change until you move out of PROG Mode.

PRESET SPEED/ RATIO SELECT TABLE

Active Parameter	Terminal Strip Input Connections TB1-4	TB1-5	Group
PS1	OPEN	OPEN	A
PS2	TB1-12	OPEN	A
PS3	OPEN	TB1-12	B
PS4	TB1-12	TB1-12	B

TB1-9 and TB1-12 are both signal common and either one can be used as a tie point for signal common.

Note: Depending on the Group selected, only two Speed or Ratio Parameters can be viewed, either Group A, PS1 and PS2, or Group B, PS3 and PS4. To view the opposite set, make the appropriate changes to the connection at TB1-5.

The setup parameters are similar to those that would be set via potentiometers or jumpers on an analog device. These are set at start up and usually do not need to be changed unless the process to be performed changes.

LO — Minimum Speed setting - Adjustable by UP and DOWN Arrow keys. Readout scaling is the same as PS1 -PS4. In Set Point Mode, the maximum value that can be set is 1/3 of scale factor SCFO. In the follower mode, the maximum "LO" value is (HI - .001). Minimum value that can be set in either mode is 0.

HI — Maximum speed setting. Adjustable by UP and DOWN Arrow keys. Readout scaling is the same as PS1 -PS4. Value is limited by SCFO (max) and 2/3 of SCFO (min) in set point mode. In follower mode, the maximum value is 9.999 and the minimum value is (LO + .001).

ACEl — Time in seconds to accelerate from zero to full speed. Adjustable by UP and DOWN Arrow keys between 0.1 and 999.9 seconds. This parameter is not displayed in follower mode.

dECl — Time in seconds to decelerate from maximum speed to zero speed. Adjustable by UP and DOWN Arrow keys between 0.1 and 999.9 seconds. This parameter is not displayed in follower mode.

FEdO Feedback resolution for the controlled motor is equal to the maximum feedback frequency divided by 30. The maximum value is 600 and the minimum is 30.

FEd1 The same as FEdO except for the master reference input used when in follower mode. Not displayed in setpoint mode.

SCFO Scale factor for readout of controlled motor. Enter the value you wish to have displayed at maximum speed. If RPM, and maximum speed is 1800 RPM, enter 1800.

SCF1 Same as SCFO except for the reference signal input. Enter value to displayed at maximum reference input frequency. Not displayed in setpoint mode.

SCdO Decimal point location for SCFO

SCd1 Decimal point location for SCF1. Not displayed in setpoint mode.

The tuneup parameters are used for the few applications where modifications to the system gain parameters are required. The default values will be acceptable for most applications. For all three gain parameters, to increase the gain decrease the value entered (50 = maximum gain for PE and IE, 5 for POSE. See Section 5.0 for detailed instructions.

PE Proportional gain adjustment. The default value is 200. The range of adjustment is 50 to 300.

IE Integral gain adjustment. The default value is 300. The range of adjustment is 50 to 2000.

POSE Position error gain adjustment. This parameter is only applicable in the follower mode. The default value is 10. The range of adjustment is 5 to 300.

1.9 MODES OF OPERATION

1.9.1 SET-POINT CONTROLLER

In the Set-Point Controller Mode the speed set-point for the controlled motor is entered by the operator on the key pad and displayed on the 4-digit display. The DS9000 compares this set-point with the signal from the feedback pulse generator and provides a control signal to the drive to reduce the error to zero.

1.9.2 FOLLOWER

In the Follower mode the set-point is calculated by multiplying the Follower reference frequency signal by a ratio entered on the DS9000 key pad by the operator.

Example:

Reference input 1800 RPM with 60 PPR generator
Ratio 0.500
Set-point is 900 RPM

As happens in the Set-Point control Mode the DS9000 compares the Set-point signal with the feedback signal and provides an analog output to the ac or dc drive so as to reduce the speed error to zero. In the Follower mode the DS9000 will bring the pulses on the output shaft into synchronization with the pulses of the Follower reference thus providing a "position lock" on the two shafts. If the ratio is changed while running the position counters are set to zero and synchronization will restart at that point.

2.0 DS9000 SYSTEM START-UP

2.1 SYSTEM COMPONENTS

A complete DS9000 drive system consists of:

DS9000 Digital Speed Controller
AC or DC Adjustable Speed Drive
AC or DC Motor with Pulse generator mounted

The AC or DC drive must be able to be controlled by a 0-10VDC input signal and must be fully operational and capable of driving the connected load at the correct speed. The AC or DC motor controlled by the drive must be fully operational and have a Pulse Generator mounted on it. The pulse generator can be a Magnetic Pick-up (Seco MTK type) or Encoder or Hall Effect device.

2.2 INSTALLATION

The procedure describes the installation of the DS9000 controller.

Caution

In cases where the digital speed controller is integrated into a customer-designed drive system, the buyer is responsible for the correct choice of required associated equipment. Incorrectly specified components may cause improper operation and/or damage to the digital speed controller.

Warning

Only qualified maintenance personnel should install the controller. They should be familiar with drive systems - including operation - and with the possible hazards resulting from improper installation practices. Serious personal injury and/or equipment damage could result if this warning is not observed.

Danger

The user is responsible for installation for the entire drive system in accordance with NFPA No. 70; with Electrical Standards for Metal-working Machine Tools, NFPA No. 70; and with all local and national codes which apply. Serious personal injury, death and/or equipment damage could result if this procedure is not followed.

2.2.1 DS9000 MOUNTING

The DS9000 controller should be flange mounted to a panel in a horizontal position. Drill patterns and dimensions for the DS9000 controller are shown in Figure 2-1. Be certain that the mounting area provides the environmental conditions noted in the following paragraphs.

To mount the DS9000 in your panel, follow these steps:

1. Cut out the mounting hole for the DS9000 as shown in the panel cutout dimensions in Fig. 2.1.
2. Remove the two socket head screws in the back of the DS9000 with a 1/16" hex wrench.
3. Remove the two slides from each side of the DS9000.
4. Slide the DS9000 through the front of the panel cutout.
5. Replace the two slides on each side of the DS9000.
6. Replace and tighten the two socket head screws.

2.2.2 AMBIENT TEMPERATURE

Ambient temperature should not exceed 50^{o}C for chassis mount unit.

2.2.3 ALTITUDE

Altitude should not exceed 1000 meters (3300 feet). Consult factory for de-rating factor for high altitude operation.

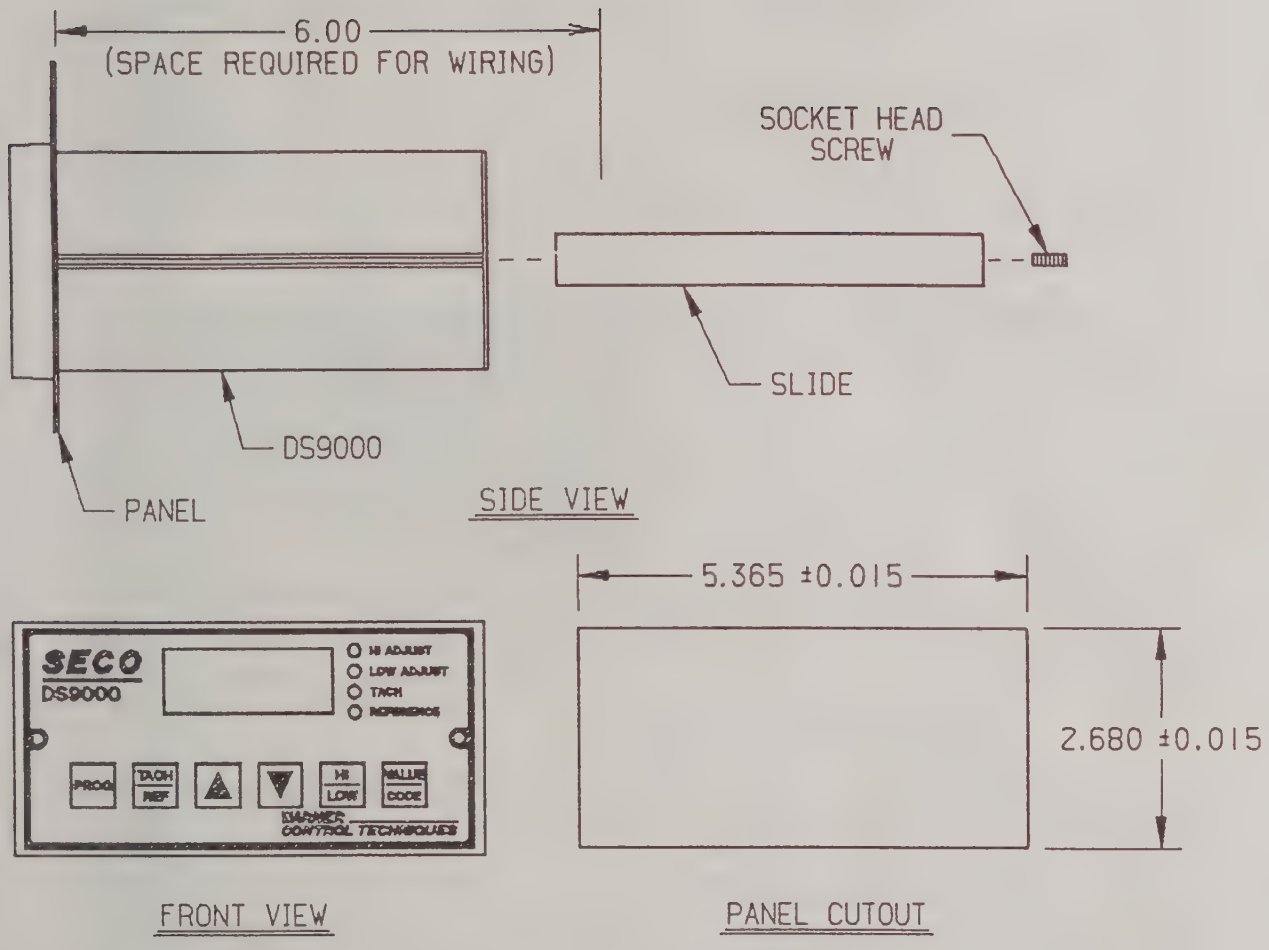

Fig. 2.1
Outline and Mounting Dimensions

2.2.4 AIR CONTAMINANTS

Ambient air should not be contaminated with caustic chemical vapors, excessive dust, dirt or moisture. If such conditions exist, the proper enclosure and cooling methods recommended for such conditions should be used.

2.2.5 MOUNTING CLEARANCES

Adequate clearance should be allowed for easy access to terminals and adjustments and to facilitate inspection and maintenance.

2.2.6 MOUNTING AREA

Mounting area should be free of vibration and have sufficient clear air circulation.

2.2.7 GROUND CONDUCTOR

An equipment ground conductor (that is, ground wire) must be connected to the controller case. This conductor must run unbroken to a drive system wire connection point--or ground bus or grounding terminal block, as local usage determines. Separate equipment grounding conductors from other major components in the system must also be run unbroken to a central connection point. These components include:

-Motor
-Isolation transformer case, if used
-Operator control panel and enclosure, if used.
-DS9000
-AC or DC Drive

2.2.8 ELECTRICAL CONNECTIONS

When connecting the equipment grounding conductor to the DS9000 controller case, permanently connect it to the grounding terminal provided.

2.3 INSTALLATION WIRING

Be sure that the AC power supplied is the voltage and frequency called for on the controller name plate. Improper voltage may damage the equipment and insufficient current will cause erratic operation of the controller. Typical connection diagrams are shown in Figures 2-2 and 2-3.

2.3.1 WIRING CODES

All interconnection wiring should be installed in conformance with the National electrical Code published by the National Fire Protection Association as well as any other applicable local codes.

2.3.2 SHIELDED CABLE

Shielded cable is required for the pulse generator, and all low-level signal circuits to eliminate the possibility of electrical interference. Connect the shield to chassis ground at the controller end of the cable only. There should not be any connections between the DS9000 signal common and any other ground or common.

2.4 WIRING THE SYSTEM

Connect the AC or DC drive in accordance with the manufacturer's instructions. Connections for Seco drives are shown in Figures 2.2 thru 2.8.

Connect the DS9000 as shown in Fig 1. Note it is important that the DS9000 Run signal is activated at the same time the drive is started.

For application flexibility, you can use several types of feedback devices with the DS9000. Refer to Fig. 2.9 for the proper connection diagram for the feedback device you are using on your system.

2.5 STARTING THE DRIVE

Install and start-up the DC or AC drive being used with the DS9000 in accordance with the manufacturers instructions. Make sure the motor shaft is free to rotate and that the magnetic pick-up or encoder or pulse generator is correctly installed. The feedback signal is to be connected only to the DS9000 and not to the DC or AC drive. The drive should be setup to run in "Armature Feedback" mode. Refer to the Drive Instruction Manual for the proper procedure to do this.

Make sure the AC or DC drive can be controlled manually using a speed potentiometer connected to signal input terminals.
Set all preset adjustments to the correct value and ensure that acceleration and deceleration controls are set at the minimum values (System acceleration and deceleration will be set by the DS9000). If the drive can be set-up to by-pass the acceleration and deceleration circuits, such as the SECO Q7000 accel jumper, adjust the drive accordingly. Set the IR Comp adjustment to minimum (usually full CCW on the IR Comp potentiometer). Turn off AC power to the motor controller.

2.6 ADDING THE DS9000

The DS9000 provides a signal that replaces the signal usually obtained from the speed potentiometer on the drive to be controlled.

The control signal from the DS9000 is isolated from ground and common on the DS9000 and the signal may be connected to non-isolated drives.

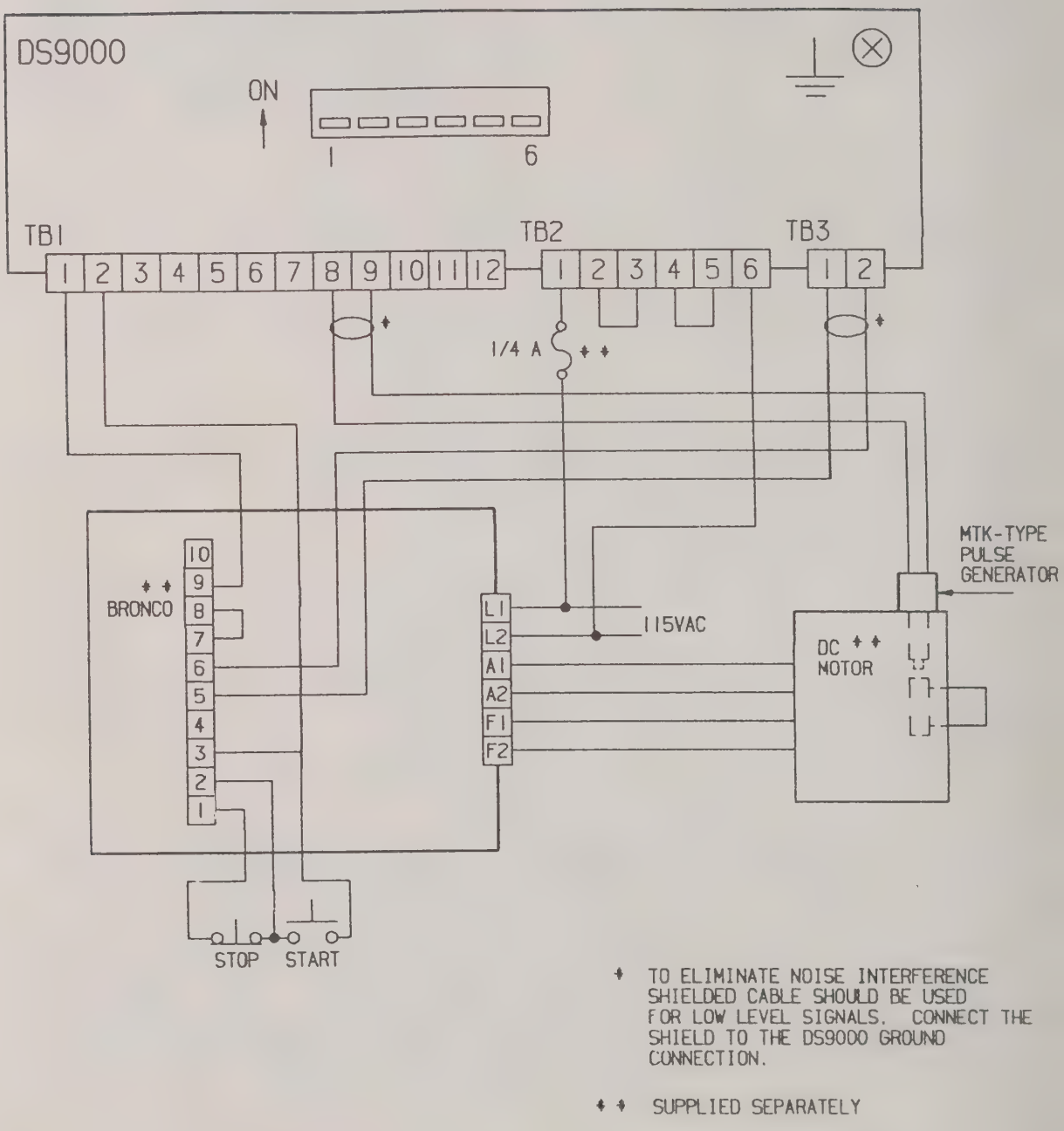

Fig. 2.2 DS9000 wiring diagram as a Set-point Speed Controller (Bronco II Series DC Motor Controller)

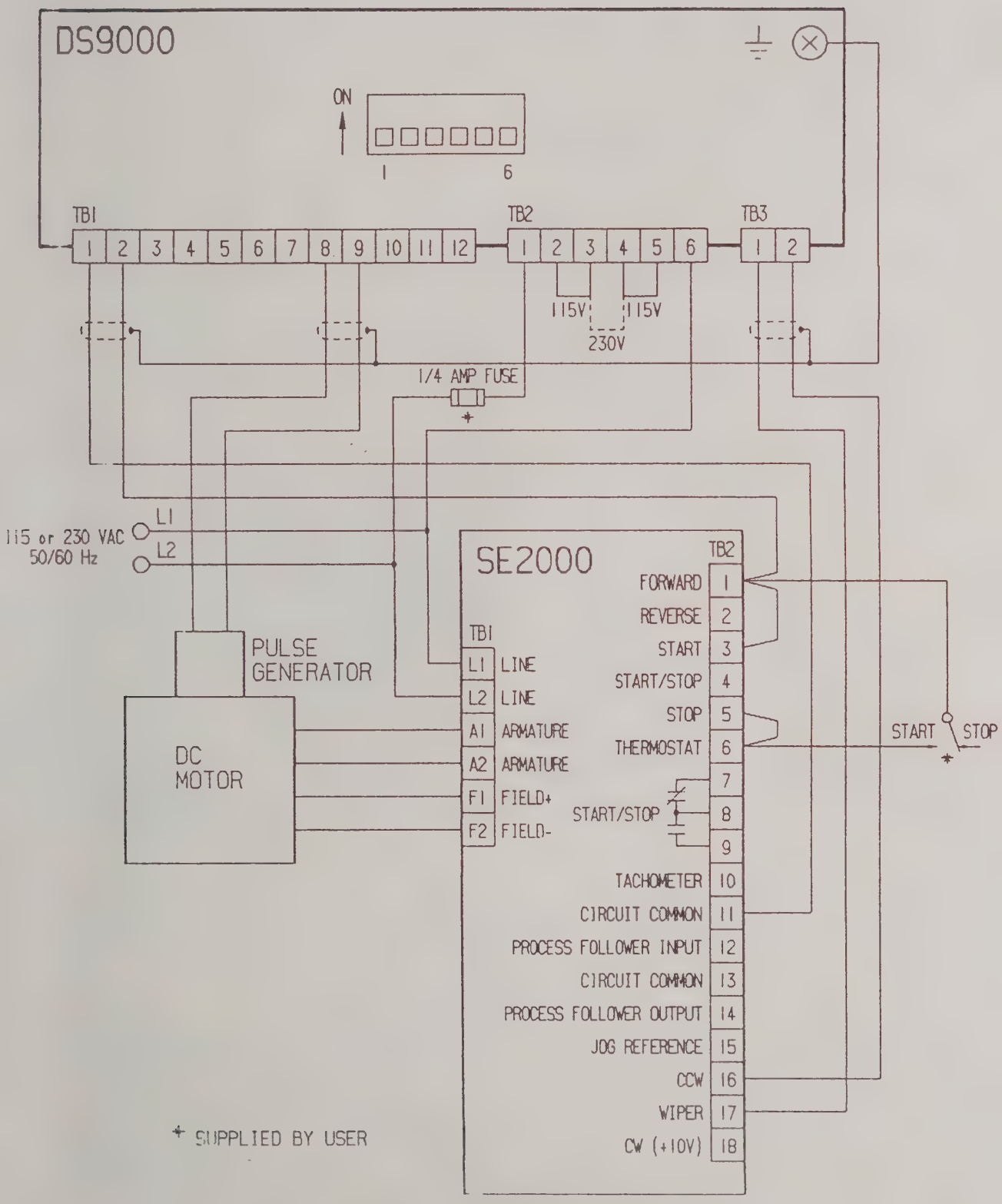

FIGURE 2.3

DS9000 WIRING DIAGRAM AS A SETPOINT SPEED CONTROLLER
(SECO SE2000 DC NON-REGENERATIVE DRIVE)

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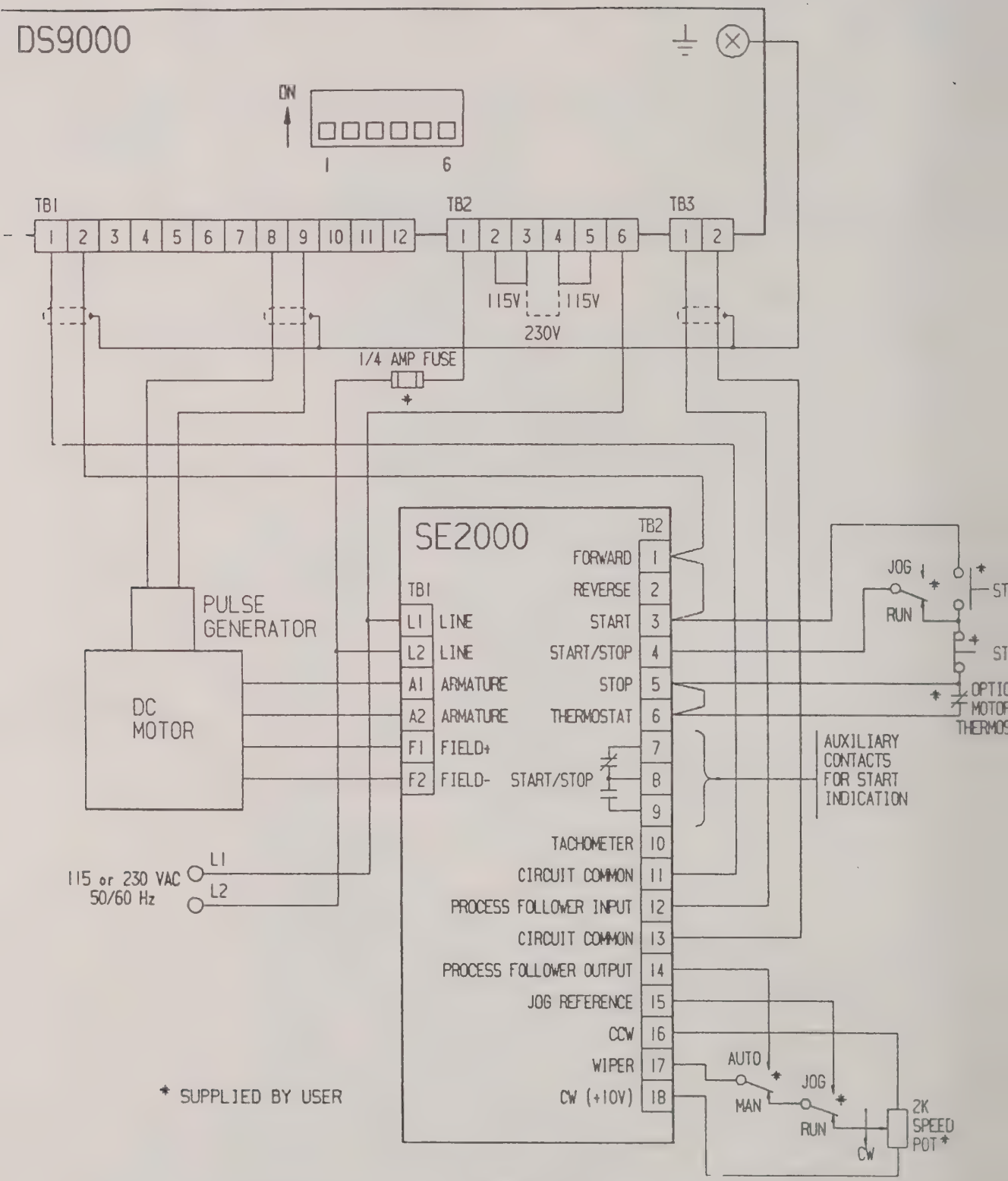
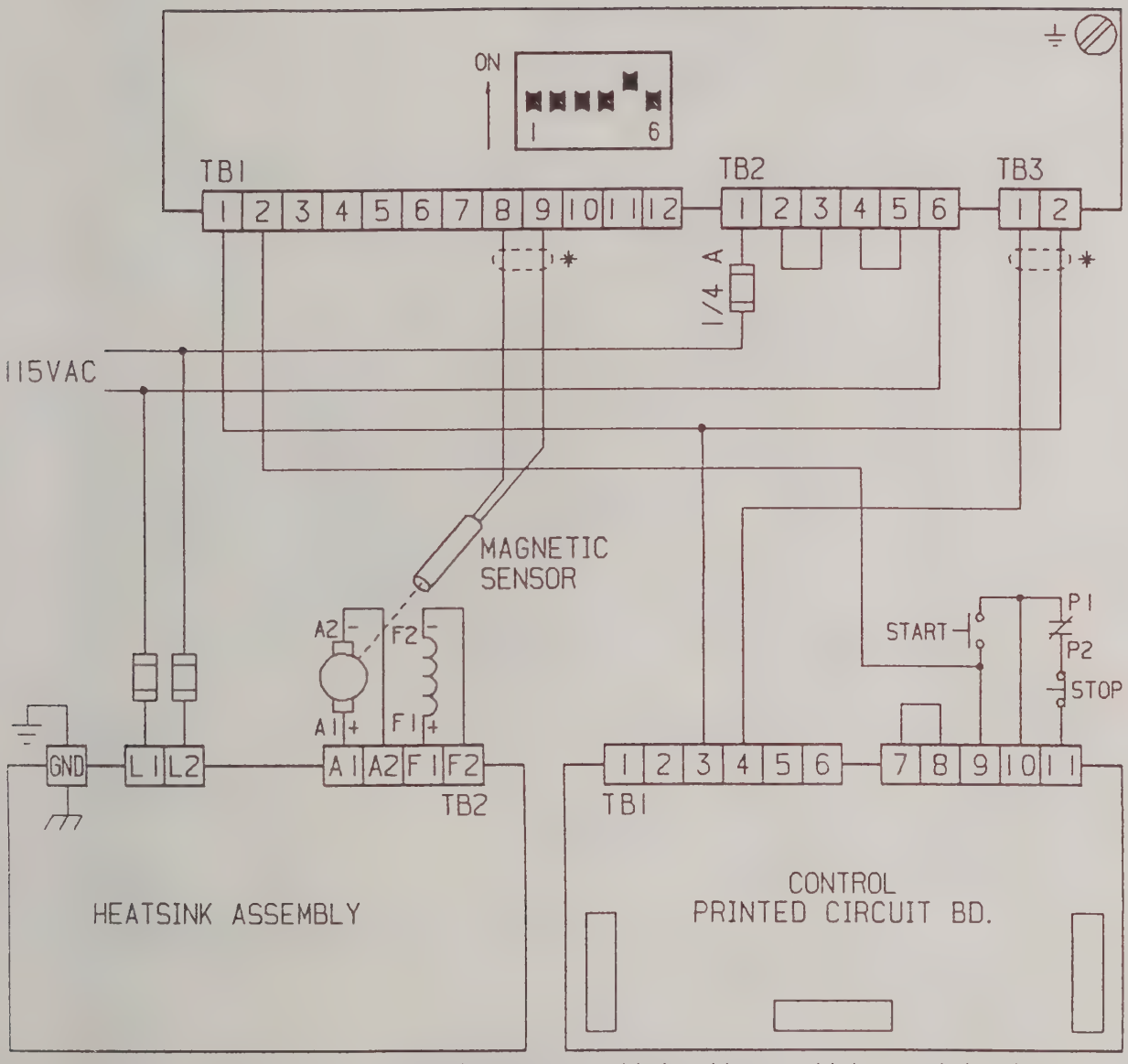


FIGURE 2.4

DS9000 WIRING DIAGRAM AS A SETPOINT SPEED CONTROLLER
(SECO SE2000 DC NON-REGENERATIVE DRIVE WITH AUTO/MANUAL)



* To eliminate noise interference, shielded cable should be used for low level signals. Connect the shield to the DS9000 enclosure ground connection.

Fig. 2.5 DS9000 wiring diagram as a Set-point Speed Controller (Q7000 Series DC Motor Controller)

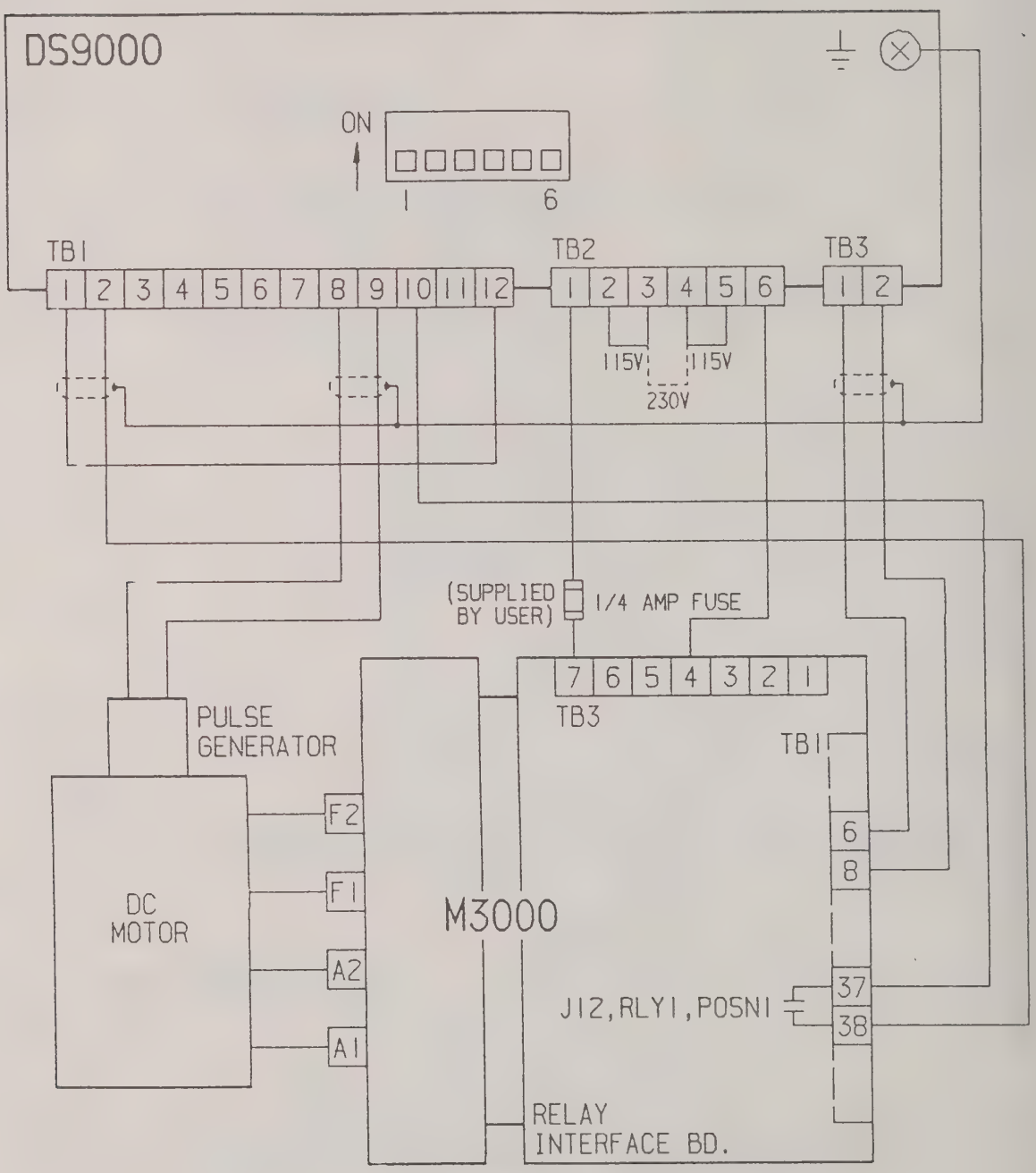


FIGURE 2.6

DS9000 WIRING DIAGRAM AS A SETPOINT SPEED CONTROLLER
(SECO M3000 DC THREE PHASE DRIVE)

55307

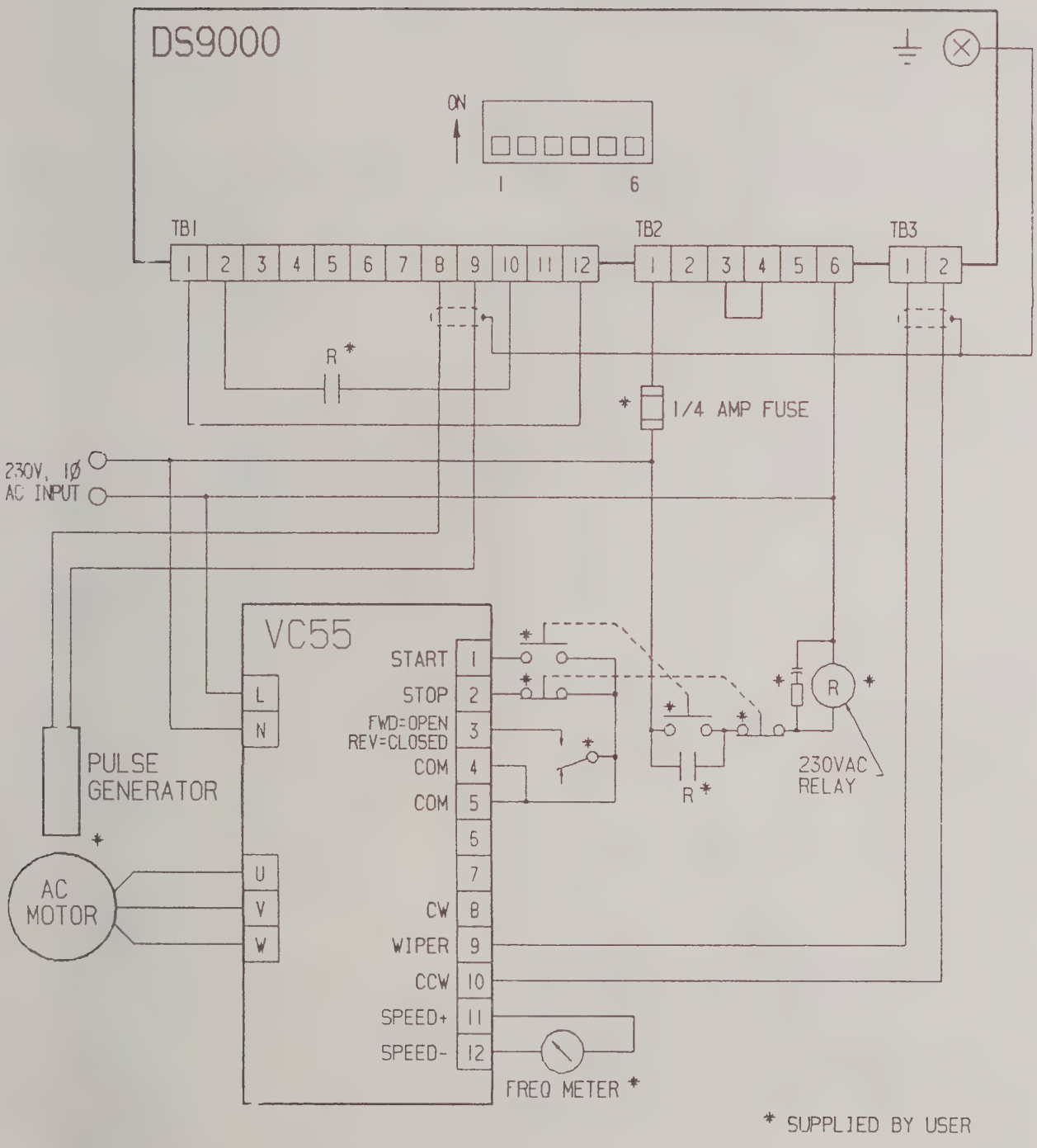


FIGURE 2.7

DS9000 WIRING DIAGRAM AS A SETPOINT SPEED CONTROLLER
(SECO VC55 AC DRIVE)

55307

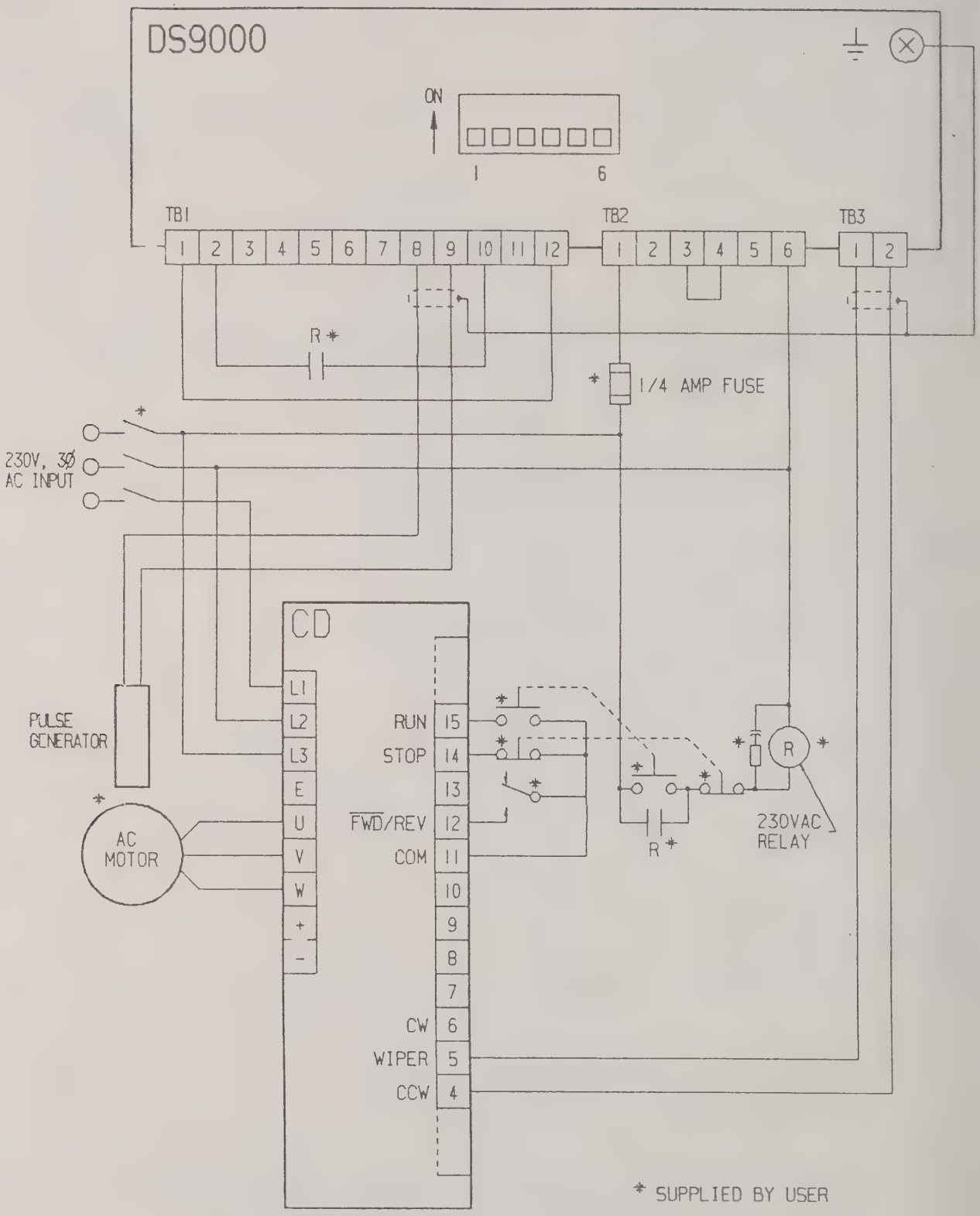
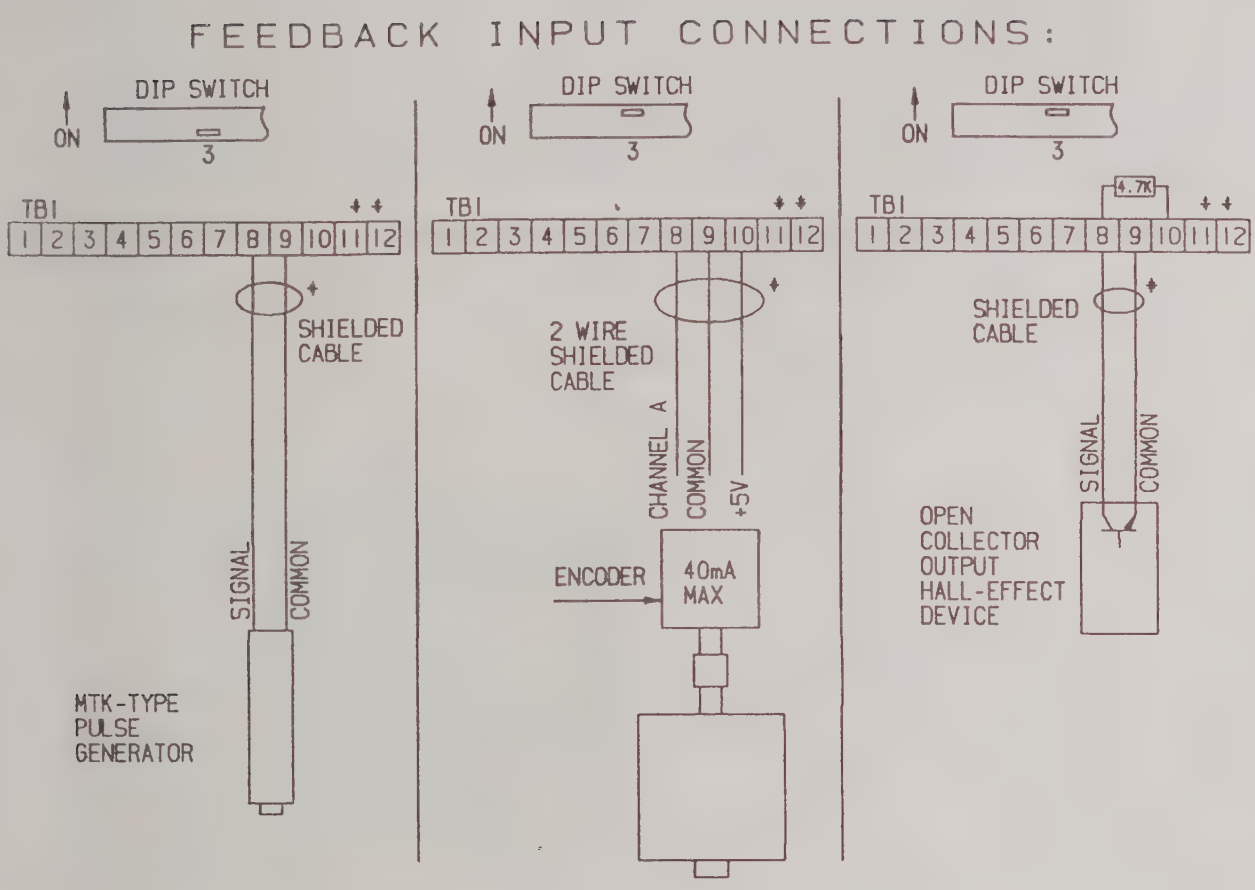


FIGURE 2.8
DS9000 WIRING DIAGRAM AS A SETPOINT SPEED CONTROLLER
(SECO CD - 230V, 3Ø AC DRIVE)



♦ TO ELIMINATE NOISE INTERFERENCE SHIELDED CABLE SHOULD BE USED FOR LOW LEVEL SIGNALS. CONNECT THE SHIELD TO THE DS9000 GROUND CONNECTION.

♦ ♦ IN FOLLOWER MODE, THE REFERENCE INPUT SIGNAL IS CONNECTED TO TERMINALS TBI-11, SIGNAL INPUT AND TBI-12, SIGNAL COMMON. THE FEEDBACK DEVICES TO BE USED AND SHIELDING REQUIREMENTS ARE THE SAME AS THAT SHOWN FOR THE CONTROLLED MOTOR FEEDBACK. DIP SW #4 APPLIES TO THE REFERENCE SIGNAL INPUT FEEDBACK TYPE SELECTION.

Fig. 2.9
Connection diagram for various pulse generators.

2.7 DS9000 PRELIMINARY SET-UP

2.7.1 INITIAL SETTINGS FOR SWITCHES

The following procedure should be followed to ensure all connections have been made correctly and that setup switches are in the correct position.

2.7.1.1 SET-POINT CONTROLLER OR FOLLOWER MODE

DS9000 units are suitable for operation as either a Set-Point Speed Controller or as a Follower. Move Dip Switch 1 to the correct position for this installation.

DipSW1
- OFF - Set-Point Controller
- ON - Follower Mode

For initial set-up select Set-Point Controller even if unit will be used as a Follower in final installation.

2.7.1.2 CLOSED LOOP/OPEN LOOP SELECT

DipSW2
- OFF - Enable PI and Position Control (Closed Loop Control)
- ON - Disable PI Controller in Set Point Control Mode (Scaled 0-10V for 0-1800 RPM)
- Disable "Position Lock" in Follower Mode (Speed Controller Only)
- When ON the display will show "OPLP" indicating Open Loop operation.

2.7.1.3 CONTROLLED MOTOR FEEDBACK SIGNAL

DS9000 units will work with several types of Feedback signals from a pulse tach generator or encoder mounted on the motor being controlled. Move Dip Switch 3 to the correct position for the feedback device in this installation.

DipSW3
- OFF - Magnetic pick-up (Seco MTK type or equivalent) or Zero Cross Over Sensor
- ON - Encoder or Open Collector type (Input impedance 3.3K)

2.7.1.4 REFERENCE MOTOR FEEDBACK SIGNAL (Follower Mode Only)

DS9000 units will follow a signal from several types of pulse tach-generators or encoders mounted on a motor or shaft. It can also follow a variable frequency signal generated electronically. Move Dip Switch 4 to the correct position for the Reference signal in this particular installation.

DipSW4 OFF - Magnetic pick-up (Seco MTK type or equivalent or Zero Cross Over Detector or electronic signal)

ON - Encoder or Open Collector type (Input impedance 3.3K)

2.7.1.5 TACH DISPLAY VALUE

The digital display in the Follower mode can show either the Reference signal or the speed of the controlled motor. Move Dip Switch 5 into the required position. This switch has no effect when used as a master or set point controller.

DipSW5 OFF - Tach display shows Reference RPM or Engineering Units

ON - Tach display shows RPM or Engineering Units of Controlled motor.

2.7.1.6 SOFTWARE REVISION NUMBER

DipSW6 OFF - No Effect

ON - Upon application of AC power, the LED Readout will display the software revision number

2.7.2 TERMINAL STRIP CONNECTIONS

In the first section of this manual, Introduction/Product Description, section 1.7.2 defined the terminal strip designations. The power input, motor controller interface, motor feedback pulse generator and master reference pulse generator signals are connected to the DS9000 via the rear panel terminal strips. Refer to Fig 2.2 and 2.3 for typical connections.

AC Input

For 115 VAC input:
Jumper TB2-2 to TB2-3
Jumper TB2-4 to TB2-5
Connect 115V AC input to TB2-1 and TB2-6

For 230 VAC input:
Jumper TB2-3 to TB2-4
Connect 230V AC input to TB2-1 and TB2-6

Motor Feedback Signal

For the motor to be controlled by the DS9000, connect the pulse generator mounted on the motor to:

TB1-8	Feedback Signal Input
TB1-9	Feedback Signal Common

For Pulse Generators that require a +5V DC voltage source, such as Encoders and Hall Effect devices, a +5V DC source has been provided.

TB1-10	+5VDC Supply Voltage (max 40ma)

Refer to Fig 2.4 for proper feedback connections

Follower Reference Signal

The master reference pulse generator, which provides the master reference signal for a Master-Follower Ratio System, is connected to:

TB1-11	Follower Reference Signal Input
TB1-12	Follower Reference Signal Common

Motor Controller Reference

The DS9000 sets the speed of the controlled motor via a 0-10 VDC analog output signal.

TB3-1	Isolated analog output, connects to the motor controller reference input (often designated as W since this is where the wiper from a speed potentiometer would be connected).
TB3-2	Isolated common, connects to the motor controller reference common (often designated as CCW since the low side or counterclockwise side of a speed potentiometer would be connected here).

Start/Stop Input

To coordinate the starting and stopping of the motor controller and the DS9000, the Start signal for the motor controller is connected to this section of the terminal strip. For detailed instructions, refer to 3.3 for a Set-Point controller or 4.3 for a Follower application.

TB1-2 Start Signal Input. For three wire Start/Stop systems, the input to the motor controller from the N.O. Start Pushbutton is also connected to this point. For two wire Start/Stop Systems, the input supplying the Start input voltage signal from the maintained contact is connected to this point. (This would be the same for a Line Start System)
If independent from the Start/Stop of the motor controller, connect to TB1-10 (+5VDC).

TB1-1 Start Signal Input Common. This terminal point is connected to the common source on the motor controller if the Start/Stop on the Motor Controller is used to start the DS9000.

If independent from the Start/Stop of the motor controller, connect to TB1-9 or TB1-12.

PRESET SPEED/PRESET RATIO SELECT

The DS9000 has four independent preset speed parameters for set point controllers or preset ratios for follower mode operation in each Parameter Data Table. The connections to TB1-4 and TB1-5 are either left open (no connection) or tied to signal common, on either TB1-9 or TB1-12. Only two parameters, Group A or Group B, can be viewed at a time. Change the TB1-5 connection for the other group.

	Terminal Strip Input Connection		
Active Parameter	TB1-4	TB1-5	Group
PS1	OPEN	OPEN	A
PS2	TB1-9 or 12	OPEN	A
PS3	OPEN	TB1-9 or 12	B
PS4	TB1-9 or 12	TB1-9 or 12	B

PARAMETER TABLE SELECT

To allow application flexibility, there are two complete independent Parameter Data Tables (A or B).

TB1-3 OPEN - Selects Parameter Data Table A.

CLOSED - Connected to Common, TB1-9 or 12, selects Parameter Data Table B.

Select a new Parameter Data Table only when the DS9000's Start input between TB1-1&2 is not present. A change in state of TB1-3 is not recognized until you stop the DS9000 (remove the Start input).

SECURITY INHIBIT

For protection of the programmed variables that make up either parameter table, when this function is turned on, the operator can only change the set point or ratio parameters, PS1 and PS2, or PS3 and PS4. This prevents accidental changes of the parameter values.

TB1-6 OPEN - Security Inhibit OFF, When the Start input is off all parameters can be changed. When the Start input is on, the first eight parameters can be changed, PS1, PS2, PS3, PS4, LO, HI, Acel or Decl.

CLOSED - Connected to Common, TB1-9 or 12 Security inhibit is on. Only the four set-point or ratio parameters can be changed, PS1, PS2, PS3 or PS4.

"OPLP" ERROR CODE

When using the DS9000 as a Follower controller, the "OPLP" error code will be displayed when the following error becomes excessive. The DS9000 is no longer maintaining a "position lock" between the controlled motor and the reference signal. The DS9000 will continue to maintain closed loop speed control. To reset, remove the Start input and then re-apply the Start input. TB1-7 is an open collector output and the user must supply a DC supply, (See Figure 1 for details) to operate a relay connected to this terminal point. When the relay is dropped out, this indicates normal operating conditions. When the relay is picked up, "OPLP" open loop or excessive following error has occured. When used as a master or Set-Point controller, the OPLP message does not indicate an error condition. (See Section 2.7.1.2 on Dip Switch #2)

TB1-7 - Connect a DC supply voltage and a relay coil in series between TB1-7 and signal common (TB1-9 or TB1-12). When the fault "OPLP" occurs, then the open collector output TB1-7 will provide a complete circuit and the customer supplied relay will pickup. (Always use a diode (1N4002-7) in parallel with the relay coil as shown in Fig. 1.)

2.7.3 SET-UP ADJUSTMENT PARAMETERS

To simplify the startup procedures for the DS9000 and motor controller, general or default values have been assigned to the operational parameters. There are seventeen operational parameters that set all of the variables required for the DS9000. Typically four of these are used during system operation. These are four preset speed parameters, PS1, PS2, PS3 and PS4. The others are set during the initial system startup and do not require further adjustment.

CAUTION:

Do not use the PROG mode to check parameter values while operating your motor drive system as improper system operation may occur. Any changes to the contact inputs on TB1 will not be recognized until you go out of PROG mode. In addition, go out of the PROG mode before restarting the DS9000. The motor will not restart until you go out PROG mode. If the tach LED is flashing, PROG mode is active, press the PROG key to move out of PROG mode.

To check the parameter values, follow these steps.

1. Apply AC power to the DS9000 but do not start up the DS9000 or motor controller. On the display you will see the speed value programmed in the active preset. If there are no connections to TB1-4 and 5, this will be PS1. The active preset will have a dash between the PS and the number. By pressing the PROG key, you will enter the program mode. Any time you are in program mode, the mode that allows you to change the parameters, the Tach LED will blink. If TB1-6 is connected to circuit common (either TB1-9 or TB1-12), open this connection to turn off the security protection. This will allow you to view the parameters when in the OFF position (no Start Input). The speed or ratio parameters, PS1, PS2, PS3, and PS4, are the only parameters that can have their values changed when you are not in the program mode.

2. While in Prog Mode, use the Value/Code Key to change between the parameter name and the value stored in that parameter. With PS1 showing on the display, the Value/Code key will toggle between PS1 and its stored value. If the value is not zero, use the DOWN key to change it to zero. The Hi/Low key changes the sensitivity of your adjustment to either units of 100 or 1. When the "Hi Adjust" LED is displayed, the UP or DOWN key changes the value in units 100. By pressing the Hi/LOW key, the "HI ADJUST" LED turns off and the "LOW ADJUST" LED turns on. Now you can change the value by units of 1. Once you have set the value to the desired value, press Value/Code so that PS1 is displayed.

3. To check the rest of the parameters, press the UP key to step to the next parameter. PS2 will be displayed. Press Value/Code to see the value. Press Value/Code again to display PS2. Only press the UP or DOWN key when the parameter name is showing. If you press the UP or DOWN key when the value is showing, you will change that value. Step through the parameters and check the values using this list.

PARAMETER CODE	DEFAULT VALUE	MAX. VALUE	MIN. VALUE
PS1	0	HI	LO
PS2 --------	0 ----	HI	LO
PS3	0	HI	LO
PS4 --------	0 ----	SCFO	0
LO	0	1/3 of SCFO	0
HI --------	1800 ----	SCFO	2/3 of SCFO
ACE1	3.0	999.9	0.1
dEC1 --------	3.0 ----	999.9	0.1
FEd0	60	600	30
SCF0 --------	1800 ----	9999	100
SCd0	0	3	0
P E --------	200 ----	2000	50
I E	300	2000	50
POSE --------	10 ----	300	5
FEd1	60	600	30
SCF1 --------	1800 ----	9999	100
SCd1	0	3	0

4. In Set-Point mode, Parameters FEd1, SCF1, SCd1, and POSE will not be displayed since they are only applicable in Follower mode. In Follower mode, ACE1 or dEC1 will not be displayed since they have no effect in this mode. Also, in Follower mode, the LO Boundary is a maximum of (HI - .001) and a minimum value of 0. The HI boundary is a maximum of 9.999 and minimum value of (LO + .001).

5. To lock in these parameters, connect TB1-6 to circuit common, TB1-9 or TB1-12.

6. If the parameters have been changed and you would like to change them back to their original default values, you could either change the parameters individually or follow the following steps to change all of them at once.

   Step 1 Turn off AC power to the DS9000

   Step 2 Press and hold down the PROG key and the Value/Code key.

   Step 3 While holding these two keys, turn on the AC power to the DS9000.

   Step 4 Release the PROG and Value/Code keys. The parameters have been changed back to their default values. Both Parameter Data Tables A and B will be reset to the default values as listed in 2.7.3 number 3.

2.7.4 Scaling the Motor Speed, Open Loop Control

To ensure proper speed scaling of the motor controller and the DS9000, the first step is to operate the system in an "open loop" mode. The DS9000 will provide a 0-10 VDC speed input signal just like a speed potentiometer. The DS9000 is not comparing the feedback signal with the reference signal as it would in "closed-loop" operation.

1. Set DipSW#2 in the ON position. This sets the DS9000 in the "Open Loop" or manual mode of operation. If you have not removed the speed pot from the drive that you used to start the drive in Section 2.5, do so now. Replace the pot with connections from TB3-1 and 2 as described in Section 2.7.2.

2. Apply AC power to the motor controller and the DS9000.

3. Set the speed, PS1 to 0. Check that TB1-4 and TB1-5 are not connected to circuit common (TB1-9 or TB1-12). This selects PS1 as the active set point parameter.

4. Start the DS9000 and motor controller via the Start/Stop method you are using, either three-wire or two-wire Start/Stop.

5. The "HI Adjust" LED should be on, if not press HI/LOW key to turn it on.

6. Press the UP key repeatedly to slowly increase the speed of the motor to 1400 RPM. The "OPLP" error code will be displayed since you are running "Open Loop". In this case that is the normal display and not an indication of an error

7. Press the TACH/REF key to toggle between the desired speed, 1400 RPM and the actual speed from the pulse generator. The "TACH" LED will be lit when the actual speed is displayed, and the "REFERENCE" LED is lit when the programmed speed is displayed.

8. With the actual speed displayed, "TACH" LED lit, adjust the max speed pot of the motor controller until you read 1400 RPM or as close as you can set it. This scales the motor controller to the DS9000 analog output.

9. Press the DOWN key until you reach zero speed.

10. Stop the motor controller and DS9000. You can see that the DS9000 is stopped if neither the "TACH" nor "REFERENCE" LEDs are lit.

2.7.5 CLOSED LOOP SPEED CONTROLLER

To provide "Closed Loop" speed regulation, that is to allow the DS9000 to compare the programmed speed to the actual speed and correct any error, put Dip Switch 2 in the OFF position. If you are using the DS9000 as a Set-Point controller, proceed to section 3.0. If you are using the DS9000 as a follower controller, refer to section 4.0.

3.0 OPERATING THE DS9000 AS A SET-POINT CONTROLLER

In the setpoint mode of operation, the DS9000 acts as a precision speed reference for a DC drive and motor. A speed in RPM or engineering units is entered by the operator using the keypad, and the DS9000 outputs a reference to the motor controller. Digital feedback is used to compare the set point to the actual speed, to correct the speed to within +/-1 RPM and to display actual speed in RPM or engineering units.

3.1 RPM PROGRAMMING/READOUT

As shipped from the factory, the DS9000 is set up to accept a selected speed as RPM, and to display motor speed in tach mode as RPM when used with a 60 pulse/revolution pulse generator. In this case, no adjustments or calibrations are necessary. If a pulse generator with a different PPR rate is to be used, the DS9000 must be calibrated to accept its input. To do so, with the DS9000 powered up, but in Stop mode, and with Security OFF, select adjustment parameter FEdO. Refer to Section 4.2 for parameter information on FEdO, SCFO and SCdO.

The parameters with a 0 on the end are for set point controllers and the parameters ending in 1 are programmed only when used as a follower controller. Set FEd0 as shown in Section 4.2. Note that the maximum value of pulses/revolution times motor RPM permitted is 25,000. Next, select adjustment parameter SCF0. This parameter sets the readout scale factor. Enter the actual maximum RPM or maximum engineering unit to be displayed at the maximum motor speed.

3.2 ENGINEERING UNITS - PROGRAMMING/READOUT

The DS9000 may be used to control and display speed in units other than RPM, provided that the units are in direct proportion to RPM and within the numerical constraints of the DS9000. Examples of this feature could include: Gallons/minute in a pumping system, feet/minute of a conveyor, or output RPM of a gear reducer. To scale the units, first check parameter FEd0 for the correct value of pulses/revolution of the pulse generator to be used. Next, select adjustment parameter SCF0. This parameter should be set to the readout desired when the MOTOR is running at the maximum speed. Minimum value is 100, and maximum is 9999. To add further flexibility, a decimal point may be located in the display. To select the decimal point position, select parameter SCd0. By entering 0, 1, 2, or 3, the decimal point will appear in positions: XXXX, XXX.X, XX.XX, or X.XXX, respectively allowing engineering units of 0.100 to 9999.

3.3 STARTING AND STOPPING

The DS9000 may be wired into the start/stop circuit of the motor controller or use the internal DS9000 +5VDC supply. To start the DS9000, a DC voltage of between 5 and 25 volts must be applied to terminals TB-1 and TB1-2. Generally this can be obtained from the DC drive's Start/Stop logic power supply. For use with typical SECO drives, see Figures 2.2 and 2.9.

To start the DS9000 with the +5V DC supply available on TB1-10 of the DS9000, connect TB1-10 to TB1-2, and TB1-12 to TB1-1. A dry contact can be placed in series with the connection between TB1-10 to TB1-2 to allow start/stop control from a switch, relay, PLC or other type of interface contact closure.

CAUTION:

Do not connect the common connection on TB1-9 or TB1-12 to the common on TB3-2. If you connect the Start/Stop of the DS9000 to the drive Start/Stop circuitry (as shown in Fig. 2.3 of the Q7000), the drive reference common TB3-2 is connected to TB1-1. You can connect TB1-1 to either the drive common or the DS9000 common but not both simultaneously without damage to the drive and DS9000.

To start the DS9000 from the Start/Stop on the drive (such as the BRONCO II , SE2000, Q7000, etc.), connect TB1-1 to the drive common (TB2-9 on the BRONCO II 160 series, TB2-11 on the SE2000, or TB1-2 on the Q7000 series). Now that common is connected, connect TB1-2 to the drive terminal point that is at a DC voltage level (i.e. -24V DC for the BRONCO II 160) when the drive has been started. This would be TB2-3 on the BRONCO II 160 series, TB2-1 on the SE2000 series or TB1-9 on the Q7000 series. For these drives or others, refer to the wiring diagrams for the particular drive that you are using in their specific installation and service manual.

3.4 HOW TO SET SPEED

Once the units of speed have been selected, setting speed is accomplished by using the UP or DOWN keys to adjust the numerical value displayed. If the TACH LED is flashing, the DS9000 is in the program mode, and PROG Key should be pressed to leave the program mode. To adjust speed in fine increments, press the HI/LOW key until the LO LED is illuminated. Each time the UP or DOWN keys are pressed, a change of one unit will occur. Holding down either key will result in a continuous increase or decrease. To quickly change speed in larger increments, press the HI/LOW key until HI LED illuminates. Each time the UP or DOWN keys are pressed, a change of 100 units will occur. In REF mode (REF LED illuminated), the display shows the speed that has been set by the operator. In TACH mode (TACH LED illuminated) the display shows actual motor speed. Select REF or TACH mode by pressing the TACH/REF key.

3.5 HOW TO CHANGE PARAMETERS

The DS9000 is made flexible and application friendly by a series of seventeen parameters which may be checked or changed from the keypad. Depending on the security mode and whether the DS9000 is running or stopped, certain parameters may or may not be accessed or changed. When the security mode is on, only the four Set Point or Ratio Parameters, PS1, PS2, PS3 and PS4 may be changed.

3.5.1 SECURITY, INHIBITING PARAMETER CHANGES

By connecting TB1-6 to circuit common (TB1-9 or TB1-12), the DS9000 security mode is activated. In this mode, the only parameters that the operator can change from the keypad are the speed setpoint (or ratio presets) PS1, PS2, PS3 and PS4. With TB1-6 open (no connection) the value of active preset may be changed simply by pressing the UP or DOWN keys. Its value may be displayed by pressing the "TACH/REF" key until the "REF" LED is illuminated. By varying the connections (switches or contacts) to TB1-4 and 5, the user can select PS1, PS2, PS3 or PS4 and display or change these parameters in similar fashion. All other parameters are locked out when the security mode is active.

3.5.2 PARAMETER CHANGES WITH DS9000 OFF (STOPPED)

When the DS9000 is in STOP mode, that is, when the START signal is off, and the security mode is not selected, all parameters may be checked and changed by the operator from the keypad. To check a parameter, enter PROG mode by pressing "PROG". The "TACH" LED will begin to blink, indicating that the DS9000 is in PROG mode. While in this mode, the DS9000 should not be started as the motor will not run until you move out of PROG mode. Pressing the UP or DOWN keys will scroll through the parameters by code name. When the parameter to be changed is reached, press "VALUE/CODE" key. The display will now indicate the VALUE of the selected parameter. To change it, press either the UP or DOWN keys. When finished, press "PROG" to return to normal display.

3.5.3 PARAMETER CHANGES WITH DS9000 RUNNING

When the DS9000 is running, or the START signal is on and security is off, only the eight basic operator adjustment parameters may be accessed. These are checked and changed in the same way as described in section 3.5.2.

As stated in Section 2.7.3, improper system operation may occur if you move into PROG mode (Tach LED will flash) while operating your system. The contact inputs to TB1 will not be recognized until you move out of PROG mode. For safe operation, follow 3.5.2 to interrogate or change parameter values.

3.6 CHANGING PARAMETER DATA TABLES (A or B)

A unique feature of the DS9000 is its ability to store and use two complete sets of user adjustments. These are called Parameter Data Tables A and B. This feature can be useful when, for example, two different processes must be run, each having its own set of parameters.

Parameter Data Table A is selected when TB1-3 is Open (no connection) and data table B when TB1-3 is connected to circuit common (TB1-9 or 12). This connection may only be changed while the START input is OFF and not in PROG mode.

Parameters that can be adjusted are shown in one of the Parameter Sets below:

OPERATIONAL PARAMETERS	PRESET SPEED 1 (PS1)
	PRESET SPEED 2 (PS2)
	PRESET SPEED 3 (PS3)
	PRESET SPEED 4 (PS4)
	MINIMUM SPEED (LO)
	MAXIMUM SPEED (HI)
	ACCELERATION TIME (ACE1)
	DECELERATION TIME (dEC1)

SET-UP PARAMETERS	FEEDBACK RESOLUTION (CONTROLLED MOTOR)-FEdO
	SCALE FACTOR (CONTROLLED MOTOR)-SCFO
	SCALE FACTOR DECIMAL POINT (CONTROLLED MOTOR)-SCdO
TUNING PARAMETERS	PROPORTIONAL ERROR GAIN (PE)
	INTEGRAL ERROR GAIN (IE)

Parameters FEd1, SCF1, SCd1, and POSE are not displayed when operating the DS9000 as a Set-Point controller. These parameters apply when using the DS9000 as a follower controller. Refer to Section 4.0 and 5.0 for information on these Parameters.

4.0 Operating the DS9000 as a Follower Controller

After the completion of the DS9000 preliminary setup instruction, as explained in Section 2.7, this section will provide a detailed procedure to operate your DS9000 as a Follower Controller, operating like an electronic gear-box, the Follower Motor will run at an exact ratio, programmable from 0.001 to 9.999, to the speed of a master motor or digital reference signal.

For a typical wiring diagram for the DS9000 connected as a Master and a Follower Controller, refer to Fig. 4.1

4.1 How to determine your ratio

The ratio entered is a multiplication factor that sets the exact scale factor of the master reference to the follower drive, up to four ratios can be programmed in parameters PS1, PS2, PS3, or PS4. For simple applications where you are following a motor with a feedback device of the same number of pulses per second as the follower motor, calculate your ratio as follows:

$$\frac{\text{Speed of follower motor (RPM)}}{\text{Speed of master motor (RPM)}} = \text{Ratio}$$

Example: $\frac{1800\ \text{RPM}}{1800\ \text{RPM}} = 1.000$

$\frac{900\ \text{RPM}}{1800\ \text{RPM}} = 0.500$ The follower will run at 50% of the speed of the master

For applications where you are using a digital reference signal or a feedback device of a different number of pulses per revolution use the following method.

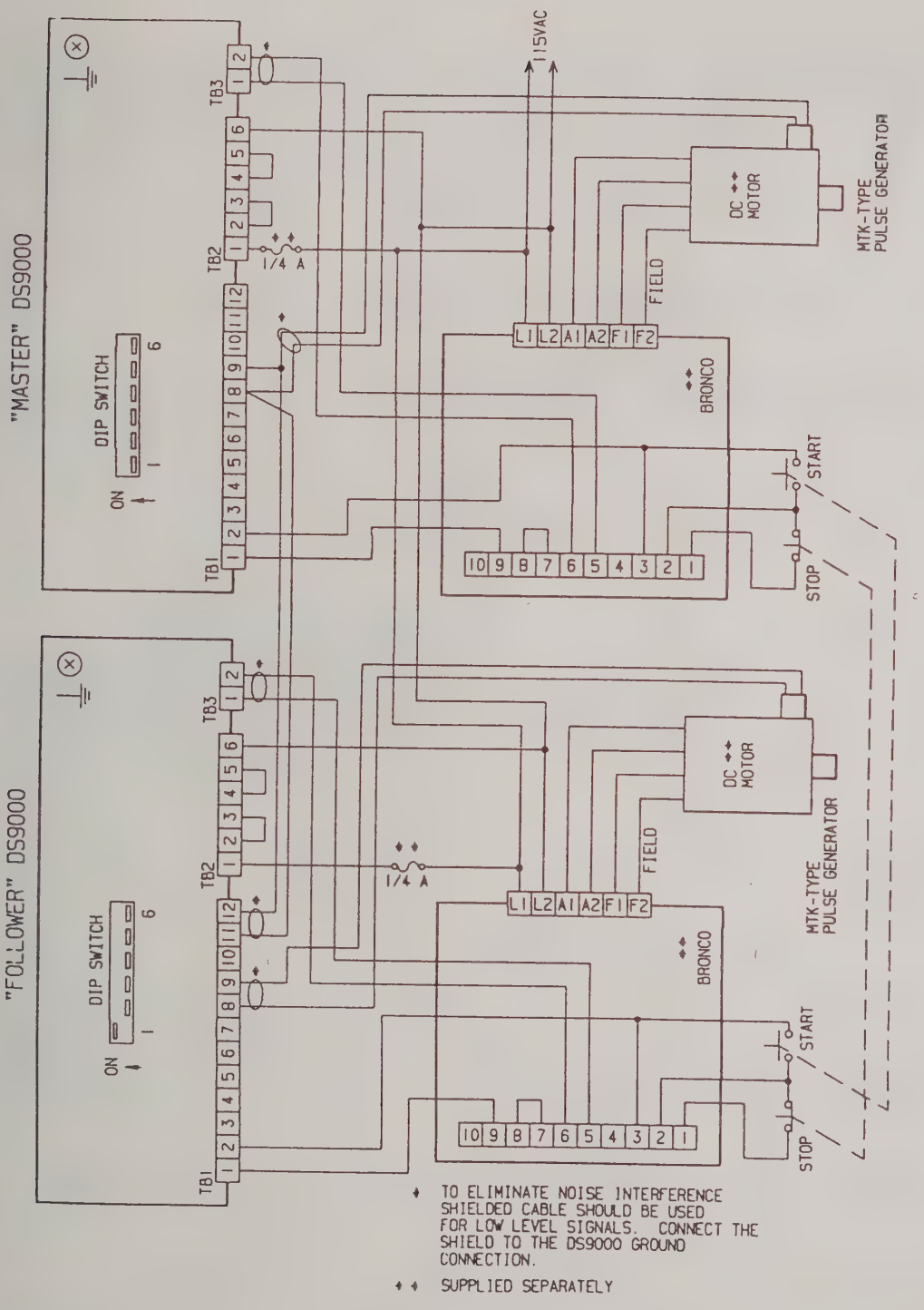


Fig 4.1
Connection digram for two DS9000 Controllers used in a Master/Follower configuration.

1. Calculate the maximum input frequency of the reference signal

$$(\text{Maximum RPM})(\text{Pulses per revolution})\left(\frac{1\text{ min.}}{60\text{ sec.}}\right) = \text{Max. Freq (Hz)}$$

Example 1 $(1800\text{RPM})(60\text{PPR})\left(\frac{1\text{ min.}}{60\text{ sec.}}\right) = 1800\text{ Hz}$

Example 2 $(1500\text{RPM})(120\text{PPR})\left(\frac{1\text{ min.}}{60\text{ sec.}}\right) = 3000\text{ Hz}$

Now that you know the maximum frequency of the input, calculate the requirements for the follower system.

$$(\text{Max output speed})(\text{PPR of feedback device})\left(\frac{1\text{ min}}{60\text{ sec.}}\right) = \text{Max Freq. (Hz)}$$

Example 3 $(1125\text{RPM})(120\text{PPR})\left(\frac{1\text{ min.}}{60\text{ sec.}}\right) = 2250\text{ Hz}$

Example 4 $(1800\text{RPM})(60\text{ PPR})\left(\frac{1\text{ min.}}{60\text{ sec.}}\right) = 1800\text{ Hz}$

Now that you have calculated the maximum reference frequency and the maximum feedback frequency for the follower, we can calculate the ratio values that would be programmed in PS1, PS2, PS3 or PS4.

Ratio calculation #1

Let's use the reference in example 1 and the follower in example 3. The equation to use is as follows.

$$\frac{\%\text{ of follower maximum}}{\%\text{ of reference maximum}} = \text{Ratio}$$

The simplicity of this is that you can use whatever units you want, Frequency, RPM, Feet per Minute or whatever engineering units you would like to use. The units have to be a percentage of whatever they are at the maximum frequency you calculated, as in examples 1-4.

To show this, let's work out two different ratios using example 1 for the reference and example 3 for the follower.

Master = 1800 Hz max input frequency @ 1800 RPM
Follower = 1125 RPM @ 2250 Hz max feedback frequency

For the benefit of this example, the master and follower are both conveyor belts, master top speed is 300 feet per minute and the follower is geared to run a maximum of 200 feet per minute.

If the follower motor is to run at 200 FPM when the master is running at 300 FPM, what is the ratio? We can solve this in three different ways. We can use percentages of frequency (Hz), motor speed (RPM) or line speed of the conveyor (FPM).

$$\frac{\%\ \text{Follower}}{\%\ \text{Reference}} = \frac{\frac{200\ \text{FPM}}{200\ \text{FPM}}}{\frac{300\ \text{FPM}}{300\ \text{FPM}}} = \frac{\frac{1125\ \text{RPM}}{1125\ \text{RPM}}}{\frac{1800\ \text{RPM}}{1800\ \text{RPM}}} = \frac{\frac{2250\ \text{Hz}}{2250\ \text{Hz}}}{\frac{1800\ \text{Hz}}{1800\ \text{Hz}}} = \frac{1}{1} = 1.0$$

Since we are looking at the percentages of the follower to the master reference, the units we use do not change the correct ratio value.

Now, we want the follower to run at 120 FPM when the master is running at 225 RPM. What is the ratio?

$$\frac{\frac{120}{200}}{\frac{225}{300}} = \frac{0.6}{0.75} = 0.8$$

Again we could have used RPMs or the input frequency to calculate the ratio.

$$\frac{\frac{675\ \text{RPM}}{1125\ \text{RPM}}}{\frac{1350\ \text{RPM}}{1800\ \text{RPM}}} = \frac{\frac{1350\ \text{HZ}}{2250\ \text{Hz}}}{\frac{1350\ \text{Hz}}{1800\ \text{Hz}}} = \frac{0.6}{0.75} = 0.8$$

4.2 RPM/Engineering Units

There are three dedicated parameters that will be programmed for follower mode operation in addition to those programmed as a master speed controller.

FEd1 - Maximum input frequency of reference motor feedback divided by 30.

SCF1 - Readout value desired at maximum reference signal input

SCd1 - Decimal point location for SCF1

To calculate the values to program into each parameter, follow these instructions.

FEd0*- $\frac{\text{Max. frequency of controlled motor feedback (Hz)}}{30}$

FEd1* - $\frac{\text{Max. frequency of master reference (Hz)}}{30}$

SCF0 - Enter number to be displayed at maximum controlled motor input frequency (max. speed)

SCd0 - Decimal point location for number to be displayed as specified by SCF0 for controlled motor readout.

*For FEd0 or FEd1, if the number calculated is less that 30, enter 30 and if the number is greater than 600, enter 600.

SCF1 - Enter number to be displayed at maximum reference signal input frequency (max. speed)

SCd1 - Decimal point location for number to be displayed as specified by SCF1 for reference signal readout.

Example A:

	Master	Follower
Motor Speed	1800 RPM	1200 RPM
Units Displayed on Readout	100.0	50.00
Feedback Resolution	60 PPR	120 PPR

Master maximum frequency is then 1800 Hz (See equation in Section 4.1-1)

Follower maximum frequency is then 2400 Hz

$$FEd0 = \frac{2400}{30} = 80$$

$$FEd1 = \frac{1800}{30} = 60$$

SCF0 = 50.00

SCd0 = 2

SCF1 = 100.0

SCd1 = 1

TABLE FOR SCd0/SCd1

Display	SCd Value
XXXX	0
XXX.X	1
XX.XX	2
X.XXX	3

4.3 STARTING AND STOPPING

The DS9000 may be wired into the Start/Stop circuit of the motor controller or use the internal DS9000 +5VDC supply. To start the DS9000, a DC voltage of between 5 and 25 volts DC must be applied to terminals TB1-1 and TB1-2. Generally this can be obtained from the DC drive's Start/Stop Logic Power Supply. For use with typical SECO drives, see Figures 2.2 to 2.8.

To start the DS9000 with the +5V DC supply available on TB1-10 of the DS9000, connect TB1-10 to TB1-2, and TB1-12 to TB1-1. A dry contact can be placed in series with the connection between TB1-10 to TB1-2 to allow Start/Stop control from a switch, relay, PLC or other type of interface contact closure.

CAUTION

Do not connect the common connection on TB1-9 or TB1-12 to the common on TB3-2. If you connect the start/stop of the DS9000 to the drive start/stop circuitry (as shown in Fig. 2.3 of the Q7000), the drive reference common TB3-2 is connected to TB1-1. You can connect TB1-1 to either the drive common or the DS9000 common but not both simultaneously without damage to the drive and DS9000.

To start the DS9000 from the start/stop on the drive (such as the BRONCO II, SE2000, Q7000, etc.), connect TB1-1 to the drive common (TB2-9 on the BRONCO II 160 series, TB2-11 on the SE2000, or TB1-2 on the Q7000 series). Now that common is connected, connect TB1-2 to the drive terminal point that is at a DC voltage level (i.e. -24V DC for the BRONCO II 160) when the drive has been started. This would be TB2-3 on the BRONCO II 160 series, TB2-1 on the SE2000 series or TB1-9 on the Q7000 series. For these drives or others refer to the wiring diagrams for the particular drive that you are using in their specific installation and service manual.

4.4 SETTING YOUR RATIO

To set your ratio, program the ratio value into PS1, PS2, PS3 or PS4 and select the desired parameter by connecting the desired combination of TB1-4 and 5 to circuit common (TB1-9 or 12). Refer to Section 1.8 for the procedures to select the desired ratio parameter. With the start input preset, DS9000 operational, pressing the UP or DOWN key in HI mode changes the value of PS1, PS2, PS3 or PS4, by units of 10 and by units of 1 in LO mode.

4.5 HOW TO CHANGE PARAMETERS

The DS9000 is made flexible and application friendly by a series of seventeen parameters which may be checked or changed from the keypad. Depending on the security mode and whether the DS9000 is running or stopped, certain parameters may or may not be accessed or changed. When the security mode is on, only the four Speed or Ratio Parameters, PS1, PS2, PS3, and PS4 may be changed.

4.5.1 SECURITY, INHIBITING PARAMETER CHANGES

By connecting TB1-6 to circuit common (TB1-9 or 12), the DS9000 security mode is activated. In this mode, the only parameters that the operator can change from the keypad are the speed setpoint (or ratio presets) PS1, PS2, PS3, and PS4. With TB1-6 open (no connection) the value of active preset may be changed simply by pressing the UP or DOWN keys. Its value may be displayed by pressing the "TACH/REF" key until the "REF" LED is illuminated. By varying the connections (switches or contacts) to TB1-4 and 5, the user can select PS1, PS2, PS3 or PS4 and display or change these parameters in similar fashion. All other parameters are locked out when the security mode is active.

4.5.2 PARAMETER CHANGES WITH DS9000 OFF (STOPPED)

When the DS9000 is in STOP mode, that is, when START signal is off, and security mode is not selected, all parameters may be checked and changed by the operator from the keypad. To check a parameter, enter PROG mode by pressing the "PROG" key. The

"TACH" LED will begin to blink, indicating that the DS9000 is in PROG mode. While in this mode, the DS9000 should not be started as the motor will not run until you move out of PROG mode. Pressing the UP or DOWN keys will scroll through the seventeen different parameters by code name. When the parameter to be changed is reached, press "VALUE/CODE" key. The display will now indicate the VALUE of the selected parameter. To change it, press either the UP or DOWN keys. When done, press "PROG" to return to normal display. The "Tach" LED will stop blinking.

4.5.3 PARAMETER CHANGES WITH DS9000 RUNNING

When the DS9000 is running, ie., the START signal is on, and security mode is off, only the eight basic operator adjustment parameters may be accessed. These are checked and changed in the same fashion as detailed in section 4.5.2.

As stated in Section 2.7.3, improper system operation may occur if you move inot PROG mode (Tach LED will flash) while operating your system. the contact inputs to TB1 will not re recognized until you move out of PROG mode. for safe operation, follow 3.5.2 to interrogate or change parameters.

4.6 CHANGING PARAMETER DATA TABLES (A or B)

A unique feature of the DS9000 is its ability to store and use two complete sets of user adjustments. These are called Parameter Data Tables A and B. This feature can be useful when, for example, two different processes must be run, each having its own set of parameters.

Parameter Data Table A is selected when TB1-3 is Open (no connection) and data table B when TB1-3 is connected to circuit common (TB1-9 or 12). This switch may only be changed while the START input is OFF and not in PROG mode.

Parameters that can be adjusted are shown in one of the Parameter sets below:

OPERATION PARAMETERS	PRESET RATIO 1	(PS1)
	PRESET RATIO 2	(PS2)
	PRESET RATIO 3	(PS3)
	PRESET RATIO 4	(PS4)
	MINIMUM SPEED	(LO)
	MAXIMUM SPEED	(HI)

SET-UP PARAMETERS	FEEDBACK RESOLUTION (CONTROLLED MOTOR)-FEdO
	FEEDBACK RESOLUTION (MASTER REFERENCE)-FEd1
	SCALE FACTOR (CONTROLLED MOTOR)-SCFO
	SCALE FACTOR (REFERENCE SIGNAL)-SCF1
	SCALE FACTOR DECIMAL POINT (CONTROLLED MOTOR)-SCdO
	SCALE FACTOR DECIMAL POINT (REFERENCE SIGNAL)SCd1

TUNING	PROPORTIONAL ERROR GAIN (PE)
PARAMETERS	INTEGRAL ERROR GAIN (IE)
	POSITION ERROR GAIN (POSE)

Parameters ACEl and dECl are not displayed when operating the DS9000 as a Follower controller. These parameters apply when using the DS9000 as a setpoint controller. Refer to section 3.0 for information on these parameters.

5.0 TUNING YOUR SYSTEM

The DS9000 utilizes a digital version of a classic proportional and integral (PI) error amplifier with reference feedforward. An error signal is generated by comparing the speed reference entered by the operator to the actual speed of the controlled motor, measured by the pulse generator.

5.1 PROPORTIONAL GAIN (STABILITY)

The proportional gain of the system is accessible by changing the parameter PE. The factory setting of PE, which should be acceptable for most applications is 200. Range of adjustment is 50 to 2000, with higher values representing a lower gain. As with all closed-loop systems, increasing the proportional gain will make the system more responsive to speed changes, causing the system to correct for error more rapidly. Too much proportional gain can cause system instability. A lower setting of PE will increase gain and make the system more responsive. If erratic or unstable operation is noted when the speed is changed, decrease the system gain by increasing the value of PE.

5.2 INTEGRAL GAIN (STABILITY)

The integral gain of the system is accessible by changing the parameter IE. The factory setting of IE, which should be acceptable for most applications is 300. Range of adjustment is 50 to 2000, with higher values representing a lower gain. The integral gain of the system allows the speed to be corrected to the set value without overshoot. Too little integral gain will cause droopy operation, with the actual speed never quite reaching, or very slow to reach, a higher set speed. To correct for this type of performance, increase the integral gain by decreasing the value of IE. Too much integral gain can cause actual motor speed to overshoot when speed reference is rapidly increased. This undesirable characteristic can be eliminated by decreasing the integral gain by increasing the value of IE.

5.3 POSITION ERROR GAIN (FOLLOWER MODE)

When used in the follower mode, the DS9000 provides a "Position Lock" between the master motor's shaft and the

controlled motor's shaft, assuming 1:1 ratio is set. With other than 1:1 following ratios, the master and follower motor shafts keep a constant relative speed. To perform this function, the DS9000 actually counts pulses from the master motor's pulse generator and maintains the same (or proportional) number of pulses from the following motor. The time taken to count and correct, thus reducing position error to zero is set by adjusting the position error. The factory setting of POSE, which should be acceptable for most applications is 10. Range of adjustment is 5 to 300, with higher values representing less gain. Sluggish response may be improved by decreasing the value of POSE. If unstable operation is noted, the value of POSE should be increased.

6.0 APPLICATIONS USING TWO OR MORE DS9000 UNITS

It is possible to construct a system of DS9000 units which will work in conjunction with each other. By utilizing the follower capability of the unit, it can be made to produce a speed related to the speed of another unit, which will automatically change with the master speed, staying proportional. Two methods of multi-unit connections may be used.

6.1 PARALLEL CONNECTION

In a parallel system, one DS9000 is used in master mode to control a motor. Two or more DS9000's programmed for follower mode may be connected to the pulse generator of the master unit's controlled motor. Each follower then has a reference from the master. A ratio may be set on each follower, for example, follower #1 - 90%, follower #2 - 80%... If the master is set for 1000 RPM, follower #1 motor will go to 900 RPM, and follower #2 motor to 800 RPM. If the master is slowed to 800 RPM, the others will follow, motor #1 at 720 RPM, and motor #2 at 640 RPM. They each maintain their set ratio with regard to the master. This is an ideal system for situations where multiple motors must run at a different, yet proportional speed with regard to a master, but their speeds with reference to each other are not important.

6.2 SERIES CONNECTION

In a series connected system, commonly known as a "Daisy chain", one DS9000 may be used in master mode to control a motor. A second unit programmed for follower mode takes its reference from the pulse generator on the master unit's motor. A third unit may then take its reference from the pulse generator on the second unit's motor. In this configuration, each unit will maintain a set ratio with regard to the previous unit in the chain. For example, follower #1 may be set for 90%, and follower #2 for 80%. If master is set for 1000 RPM, follower #1 motor will go to 900 RPM, and

follower #2 motor will go to 720 RPM. The ratio is with regard to the previous unit, not the master. This is an ideal system for use when a certain percent "draw" between units must be maintained as line speed is changed.

7.0 SYSTEM TROUBLESHOOTING

In this section, we will provide guidelines to assist in restoring the DS9000 to proper operation.

7.1 ERROR CODES

The only error code that will be displayed on the readout is "OPLP". This means "Open Loop" and will be displayed in two different circumstances. When DipSW2 is in the ON position, the DS9000 is running "Open Loop". The DS9000 is not correcting any error between the programmed speed and actual speed but just giving a 0-10V DC signal in response to the programmed speed. The "OPLP" display is a normal display during this mode of operation and is not considered an error code.

When using the DS9000 as a follower controller, the error code, "OPLP", indicates excessive error between the master reference and the Follower motor feedback. This could occur if the follower motor was either stopped or running in current limit and not able to maintain the desired speed ratio. The error would accumulate until the "OPLP" error code is displayed. If the signal from the follower motor feedback was lost through an open connection, then this would also cause the error code to appear.

An output connection, TB1-7, is an open-collector output that provides the user with a signal to his external system that a "OPLP" error has occured. Refer to Figure 1 for correct wiring directions. A relay coil and DC supply source can be connected between TB1-7 and circuit common (TB1-9 or 12). TB1-7 provides a current sink when the excessive following error condition occurs. When the error code "OPLP" is displayed, the DS9000 no longer maintains the position with the master reference, but operates as a speed control. To reset the DS9000 to maintain position lock, temporarily remove the Start input. When the Start input is reapplied, the DS9000 will again maintain position synchronization of the follower motor with the master reference.

7.2 TROUBLESHOOTING TIPS

7.2.1 SYSTEM TROUBLESHOOTING

If the system is not operating as it should, the best approach is to divide the total system into its basic components and decide which ones could be contributing to the problem. These

basic system blocks would include the DS9000, Motor Controller, Motor, Operators (Start, Stop, Run/Jog, Auto/Manual, etc), feedback devices, AC input and interconnection wiring.

7.2.2 TERMINAL STRIP CONNECTIONS

A frequent cause of many types of system malfunctions can be traced to loose wire connections or miswired connections. Check all terminal strip connections for tightness or misconnections. A misconnection is more likely to occur during the initial start-up than during normal operations.

7.2.3 DIPSWITCH POSITION

Contact closure input changes to the DS9000 will not be recognized when in PROG mode. When you move out of PROG mode, the DS9000 will update the status of the inputs. The parameter data tables, A or B, can only be changed in the stopped state, (no Start input).
Since the DS9000 is designed to be flexible in its use for varied applications, the improper placement of any of the DS9000 Dipswitches can cause improper operation. You should keep a list of the correct Dipswitch connections for easy referral in case one gets accidentally switched to the wrong position. For your convenience, use the worksheets found in Section 8.0.

7.2.4 DATA PARAMETERS

Just as the Dipswitches are designed for flexibility, the parameters are also used to allow easy adjustment to suit your application. If any of these are improperly changed, the operation of your system may be impaired. A list of parameter values should be kept handy to allow for easy cross-reference. For you convenience, use the worksheets found in Section 8.0.

7.2.5 VOLTAGE CHECKS

To assist in your system troubleshooting the following voltage checks could be made.

TB1-2 to TB1-1	Typically +/-24VDC when started; OV when stopped.
TB1-3 to TB1-12	5 VDC when Parameter Data Table A is selected. 0 VDC when Parameter Data Table B is selected.
TB1-4 to TB1-12	5 VDC when Speed Group A is selected 0 VDC when Speed group B is selected.

TB1-5 to TB1-12	5 VDC selects PS1 if Group A, PS3 if Group B. 0 VDC selects PS2 if Group A, PS4 if Group B.
TB1-6 to TB1-12	5 VDC if security mode is off. 0 VDC if security mode is on.
TB2-1 to TB2-6	AC input voltage. Jumpers on TB2-2 toTB2-3 and TB2-4 to TB2-5 for 115 VAC, jumper on TB2-3 to TB2-4 for 230 VAC.
TB3-1 to TB3-2	DC analog output, 0-10 VDC depending on programmed speed. 0-10VDC represents zero to full speed.
TB1-10 to TB1-12	+5 VDC power supply

7.2.6 PULSE TRAIN INPUT (FEEDBACK AND REFERENCE INPUT)

When used in the zero-crossing configuration (DipSw 3 or 4 down), the DS9000 is capable of sensing signals of less than 30mV. Therefore proper shielding of all signal wires is required (i.e. low output voltage from the sensor.) If a problem does occur, as evident by the motor not running at low speeds, insure that the drive and motor are properly grounded. Also, a small resistor (1000) across the mag-sensor terminals can help eliminate low levels of noise coupling. An easy way to verify a noise problem is to start the DS9000 and put it into TACH mode (push the TACH key). If it reads anything other that "0" and the motor shaft is not turning then the DS9000 is picking up noise!

8.0 PARAMETER CODE/VALUE WORKSHEETS

Once the system parameters have been determined to fit your application, complete the following worksheet to keep a permanent record of the parameter values and dipswitch positions. This can help prevent system downtime in case of an accidental parameter or dipswitch change.

PARAMETER CODE/VALUE WORKSHEET

PARAMETER CODE

MASTER	FOLLOWER	DEFAULT	DATA TABLE "A"	DATA TABLE "B"
PS1	PS1	0	_____	_____
PS2	PS2	0	_____	_____
PS3	PS3	0	_____	_____
PS4	PS4	0	_____	_____
LO	LO	0	_____	_____
HI	HI	1800	_____	_____
ACE1	-	3.0	_____	_____
dEC1	-	3.0	_____	_____
FEdO	FEdO	60	_____	_____
SCFO	SCFO	1800	_____	_____
SCdO	SCdO	0	_____	_____
PE	PE	200	_____	_____
IE	IE	300	_____	_____
-	POSE	10	_____	_____
-	FEd1	60	_____	_____
-	SCF1	1800	_____	_____
-	SCd1	0	_____	_____

DIPSWITCH #	1	2	3	4	5	6
DEFAULT	OFF	OFF	OFF	OFF	OFF	OFF
SYSTEM SETTING	__	__	__	__	__	__

Once you have completed the system start-up, fill in the exact parameters and dipswitch positions selected for your system.

To restore both Data Tables (A and B) to their default values, turn off the AC input and while pressing both PROG and VALUE/CODE keys, turn on the AC input.

PARAMETER CODE/VALUE WORKSHEET

PARAMETER CODE

MASTER	FOLLOWER	DEFAULT	DATA TABLE "A"	DATA TABLE "B"
PS1	PS1	0		
PS2	PS2	0		
PS3	PS3	0		
PS4	PS4	0		
LO	LO	0		
HI	HI	1800		
ACE1	-	3.0		
dEC1	-	3.0		
FEdO	FEdO	60		
SCFO	SCFO	1800		
SCdO	SCdO	0		
PE	PE	200		
IE	IE	300		
-	POSE	10		
-	FEd1	60		
-	SCF1	1800		
-	SCd1	0		

DIPSWITCH #	1	2	3	4	5	6
DEFAULT	OFF	OFF	OFF	OFF	OFF	OFF
SYSTEM SETTING						

Once you have completed the system start-up, fill in the exact parameters and dipswitch positions selected for your system.

To restore both Data Tables (A and B) to their default values, turn off the AC input and while pressing both PROG and VALUE/CODE keys, turn on the AC input.

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